YORK

YMAE Application Guide

YMAE Air-to-Water Inverter Scroll Heat Pumps

The power behind **your mission**

Johnson Controls

Introduction

The YORK® YMAE air-cooled full DC inverter modular heat pump provides chilled and hot water for all air conditioning applications using an air handling or terminal unit. The unit is completely self-contained and designed for outdoor installation at roof or ground level. Each packaged unit includes hermetic scroll compressors, liquid heat exchanger, air-cooled condensers, R-454B refrigerant, and a weather-resistant microprocessor control center, all mounted in a sheet metal frame. Units are suitable for single or multiple unit installation with the possibility to connect up to 32 modules together in one control group network. Up to four modules can be provided as a factory package with single point electrical connection. The unit is available as either a two-pipe reversible heat pump or four-pipe simultaneous heating and cooling machine, with load balancing capability enabled by the air-source heat exchanger.

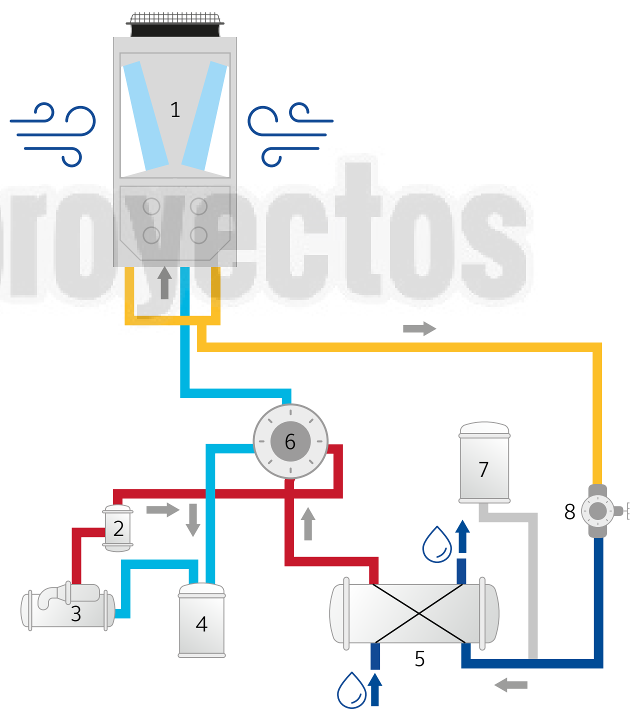
Control principles

Air-to-water heat pump unit modes of operation
The YMAE two-pipe heat pump has two operation modes: cooling only or heating only. A reversing valve changes the function of the heat exchangers to provide either heated or cooled liquid as required. A third operating mode, defrost cycle, is enabled automatically as necessary to remove ice build-up when the unit is in heating operation.

The YMAE four-pipe heat pump has three operation modes: cooling only, heating only, and simultaneous heating and cooling. Intelligent control logic of operation mode can meet dynamic cooling and heating load in one building, offering an integrated cooling and heating solution. A fourth operating mode, defrost cycle, is enabled automatically as necessary to remove ice build-up when the air source heat exchanger is functioning as an evaporator.

Cooling mode
Low-pressure liquid refrigerant enters the heat exchanger and is evaporated and superheated by the heat energy absorbed from the chilled liquid. Low-pressure vapor enters the compressor through the four-way reversing valve and accumulator, where pressure and superheat are increased. The high-pressure vapor is fed to the ambient coils and fans through the four-way reversing valve, where heat is removed. The fully condensed and subcooled liquid passes through the expansion valve where pressure is reduced and further cooling takes place before returning to the heat exchanger.

Figure 1: Cooling and defrost mode PID example



1	Ambient coils	5	Heat exchanger
2	Oil separator	6	Four-way valve
3	Compressor	7	Receiver
4	Accumulator	8	EEV

Note: This diagram is for reference only, it does not represent the actual PID.

Heat pump mode

Liquid refrigerant enters the ambient coil and is fully evaporated and superheated by the energy absorbed from the ambient air. Low-pressure, superheated refrigerant vapor passes through the four-way reversing valve and the accumulator and enters the compressor, where pressure and superheat are increased. High-pressure, superheated refrigerant vapor enters the water plate heat exchanger where heat is rejected to the water. The high-pressure liquid refrigerant, leaving the plate heat exchanger passes through the liquid receiver and enters electronic expansion valve (EEV) where the refrigerant pressure is reduced and subsequently cooled before returning to the ambient coil.

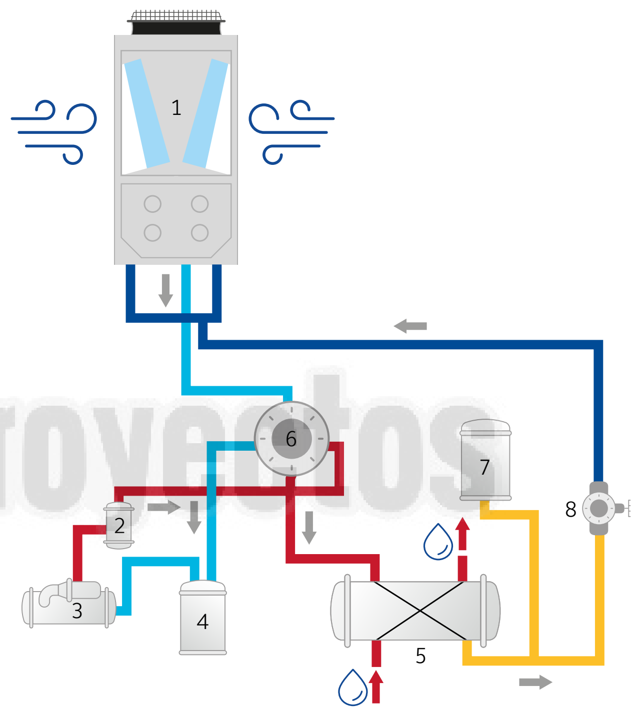
Defrost mode

When ice builds up on the ambient coils, an automatic defrost cycle is initiated with the machine in a cooling mode. Each of the refrigerant circuits are defrosted separately. When in defrost mode, the circuit operating in heat pump mode is in balance with the circuit operating in defrost (cooling). Heat output is, at worst case, net zero during defrost period.

Advanced defrost logic is employed to reduce defrost cycle time and system impact. This includes the following capabilities:

- Defrost based on the refrigerant pressure
- Subcooling circuits are designed to prevent ice build-up at the bottom of the coil
- Defrost staging logic that cycles circuits through defrost sequentially, minimizing deviation from setpoint during defrost. No more than half of the total number of circuits can defrost at the same time. In the most extreme case, the system provides net zero heating output for the defrost period
- The defrost generates water, which collects in the unit drain pan below the coils and channels out of the bottom of the unit frame through large diameter flexible tubing. The drain pan and tubing are freeze-protected by the heat generated inside the unit cabinet. Include a drain under each unit to collect condensate water and move it away from the working area surrounding the unit

Figure 2: Heat pump mode PID example



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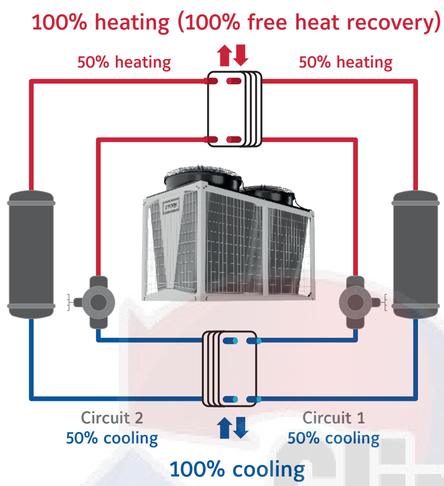
Simultaneous heating and cooling mode, four-pipe unit

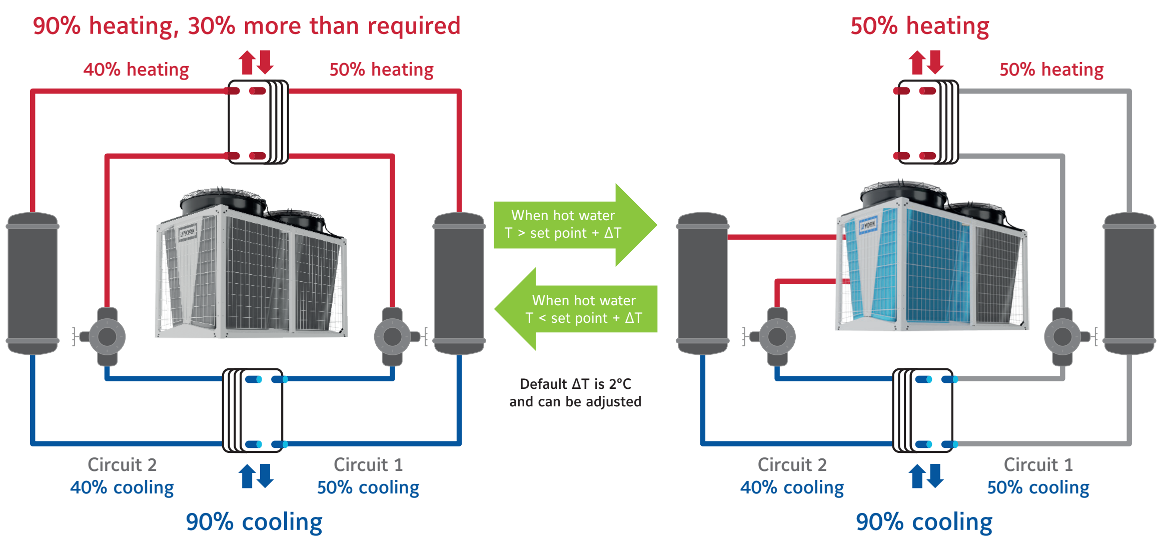
The heat pump can simultaneously provide both heating and cooling to different zones or areas within a building.



Control logic auto-balances cooling and heating within the YMAE four-pipe heat pump allowing independent and dynamic control of both hot and chilled water temperatures. Auto-balance logic also maximizes the utilization of cooling with heat recovery to improve energy efficiency.

For example, the following figure shows a system in operation, targeting 90% cooling and 60% heating.

Figure 3: Ambient heat exchanger



Firstly, the unit meets the 90% cooling demand and recovers 90% of heat while working as simultaneous cooling and heating. Heating is 30% more than the demand, so it switches to the right side and provides 50% heat, which is 10% less than the demand. With the mode switching control, 90% cooling and 60% heat is achieved.

To avoid the unit frequently shutting off and turning on cycling and to ensure water temperature is stable, the building system water volume needs to be above the recommended value.

Sequence of operation

The following section describes the start-up process after unit power-up, loading and unloading, and the defrosting process:

1. After applying power supply to the system, the microprocessor performs pre-check to ensure that the daily or holiday schedule and any remote interlocks allow the unit to run, all safety cut-outs are satisfied, and no faults are unsettled. Any problems identified during the pre-check are shown on the HMI display
2. The unit can start automatically based on an internal schedule function, without user or building management system (BMS) manual input command every time. When the unit is on, the water pump will be controlled to start working instantly and the water valves will be open (if with water valve). The unit then detects the status of the flow switch to ensure sufficient liquid flow is supplied. The water pump should be controlled by leader heat pump module
3. If there are no problems, the unit will be ready for loading process depending on customer load requirement. The control system adjusts the unit load depending on the liquid temperature and temperature change rate. If operating at a high load demand, the controller increases the speed of the inverter compressor or turns on more compressors. If there is a low load demand, the inverter compressor may continue to operate at low speed or may simply stop. If the latter is the case, one compressor restarts automatically when needed
4. When a compressor is running, the controller monitors the discharge/suction pressure and various other system parameters such as liquid temperature, ambient temperature, and heat exchanger temperature. If any problems are detected, the control system takes appropriate action and displays the related fault message on the HMI display
5. The corresponding EC fan works when the compressor starts in cooling and heating mode. Fan speed is automatically adjusted based on system pressure, ambient temperature, and other key parameters
6. Each system is configured with a main EEV in the liquid line between the condenser and the evaporator. The device automatically adjusts opening steps to satisfy refrigerant flow demand, mainly based on the difference between the actual and target suction superheat
7. If demand requires, more compressors will start up either from another system in dual circuit units, or another unit in a modular control system. The sequence is as follows:
   a. Load compressors to meet the frequency increase requirement
   b. Load compressors in the standby modules. The priority is to run compressors with fewer running hours
   c. Load any other compressors, also those with fewer running hours
8. Modular array packages can be regarded as a single unit with multiple circuits. The customer can set a unique address for each single module through a dip switch on the control board located in the electrical panel. One module is set as the Leader, and all circuits are managed by a centralized controller. When loading or unloading, each circuit is independent but given equal priority if it has similar running speed and running hours. For example, when two circuits need to be loaded, they can be two circuits in the same module or two circuits in two different modules.
   The centralized controller monitors and records the cumulative running duration of each circuit compressor in real time. When loading, the compressor with a shorter accumulative running time has higher priority. When unloading, the compressor with longer accumulative running hours is in higher priority to unload.
   Between one and three compressors can be loaded at any one time, which is based on the total number of modules in one control network and the loading requirement
9. As the load decreases below the setpoint, the compressors shut down in sequence. This normally occurs at intervals of between approximately 20 seconds and 40 seconds based on water temperature as compared to the setpoint and the rate of temperature change

10. When the compressor in a system is unloading to shut off, the system switches off its fan and then the EEV shortly afterwards

11. The compressor heaters energize at a specific ambient temperature to prevent liquid refrigerant condensing and accumulating in the compressor housing and to prevent the liquid flooding and oil lubrication risk

12. YMAE simultaneous cooling and heating loading and unloading priority:
    - If both cooling and heating require loading, priority is to load systems running in cooling and heating operation. After heating load meets requirement, continue loading systems running in cooling operation
    - If both cooling and heating require unloading, priority is to unload systems running in cooling and heating operation. If the heating load meets the requirement, continue unloading systems running in cooling operation

13. When multiple modules are packaged together, the capacity of each circuit is 1/2n of the total capacity, where n is the number of modules. When the unit is running, the following processes can occur:
    - If only cooling or heating is required, the unit loads step by step and operates in cooling only or heating only mode until it meets the required capacity
    - If cooling and heating are both required simultaneously, the unit starts up with the cooling and heat recovery mode. The unit loads the circuits step by step until it meets the required capacity for cooling or heating, whichever is lower. Then, for the remaining cooling or heating capacity, the unit continues to load other circuits and operate in cooling only or heating only mode until the remaining capacity is met
    - If the cooling and heating recovery mode has been loaded into the last circuit, this last circuit switches between the cooling and heat recovery mode and cooling only or heating only mode

14. To mitigate adverse effects on system performance due to air-source heat exchanger frosting, the unit intermittently activates defrost mode when the following conditions are met:
    - If the coil temperature is less than or equal to the target temperature for three minutes and the cumulative heating duration is greater than or equal to 40 minutes. The default target ambient temperature is 44.6°F (7°C)
    - If the saturated suction temperature is less than or equal to the target temperature for three minutes and the cumulative heating duration is greater than or equal to 40 minutes. The default target ambient temperature is 42.8°F (6°C)
    - The system cumulative heating duration is greater than or equal to 180 minutes when ambient temperature is below 14°F (-10°C)

15. In defrost mode, a unit runs a reversed refrigeration cycle and air-to-water heat pump heating capacity is diminished as a result

16. When ice builds up on the ambient coils, operate the unit in defrosting mode to remove defrost. The number of defrosting circuits must not exceed half of the total number of circuits. When in defrost mode, the circuit operating in heat pump mode is in balance with the circuit operating in defrost. Heat energy is not removed from the hot water system because the controller minimizes the quantity of circuits that can defrost at any one time. Less than half of total circuits can enter defrost at any time, which reduces heating capacity loss and helps minimize the temperature impact on the system

Leak detection control scheme

The leak detection sensor and ventilation fans are installed inside the enclosure to avoid any refrigerant accumulations in case leakage occurs. The sensor is located near the compressor mounting base where the piping is most densely arranged.

The ventilation fans run for 60 seconds when the unit is powered on for the first time, and periodically for 30 seconds every 24 hours. When the refrigerant concentration reaches 25% of low flammable limit (LFL) the fans start to extract the gas mixture from the enclosure and the unit shuts down, with the exception of the ventilation fans if the concentration reaches 50% of LFL.

The leakage sensor is a non-dispersive infrared (NDIR) sensor. The sensor is calibration-free and designed for a lifespan of 15 years.

Figure 6: Two-pipe gas sensor location

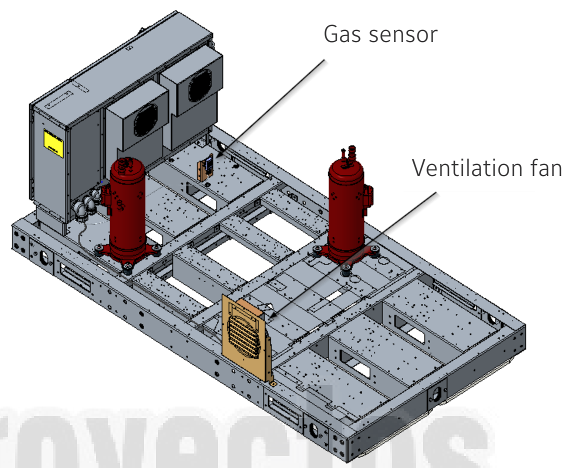
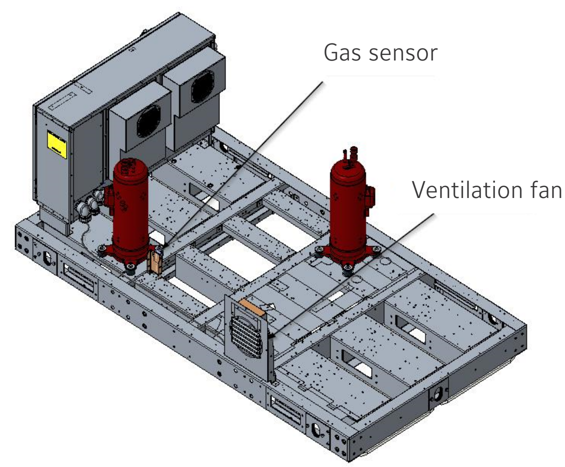


Figure 7: Four-pipe gas sensor location



System and unit sizing

Correct system design considers the range of potential operating conditions, system and heat pump equipment sizing, and any requirements for redundancy. Commonly used high-temperature, hot-water conditions do not only result in high system energy consumption but are not even attainable with commonly available heat pump technologies. The common high-temperature heating assumptions of the past must be abandoned and low-temperature supply heating concepts embraced. Historic "rules-of-thumb" for system capacity sizing must be reconsidered.

Computerized load analysis for new buildings and accurate load history for existing buildings is essential for designing the correct system and meeting owners' environmental and financial goals. This section discusses many of the important aspects of system design relative to an air-cooled heat pump modular unit in a system.

Size guidelines - minimum module quantity

The minimum unit design principles for air-cooled heat pumps can be considered based on the following aspects:

Load requirements: Evaluate the heating and cooling load demands of the building or space. Consider factors such as building size, usage, occupancy and equipment heat load to determine peak and average load requirements. In general, sizing for either greater heating or greater cooling demand is recommended, but building operation and usage may determine the most appropriate system design.

The design temperature of heating water should also be carefully considered. Higher temperatures will reduce heat pump efficiency but offer savings on terminal unit sizing and are often necessary for retrofits. Lower water temperatures are recommended, especially for new construction.

Single-unit capacity: Based on the load requirements and heat pump performance data, determine the minimum capacity of a single heat pump. Ensure that a single unit can meet the minimum load demand to provide sufficient heating and cooling capacity even at low loads.

Defrost derating: Defrost operation results in a weighted performance derate to the equipment heating capacity. The published rating report includes a derated capacity considering average defrost, in accordance with EN14511:2013. Consideration of site conditions by the design engineer is recommended, in order to consider additional derate in case of unusually high humidity.

Low outdoor air temperatures cause the outdoor coil temperature to drop below freezing potentially resulting in frost accumulation. Defrost typically only occurs below 47°F (8.3°C) OAT. Air-to-water heat pump units automatically enter defrost operation when required. The YMAE unit control has intelligent defrost control to minimize defrost while maximizing unit heating efficiency and capacity. The controls algorithm minimizes the quantity of circuits allowed to defrost. Less than half of total circuits enter defrost at any one time, which reduces heating capacity loss and helps minimize the temperature impact on the system.

Turndown rate: Turndown rate refers to the ability of a heating or cooling system to reduce its output capacity or energy consumption below its maximum rating. It indicates the range over which the system can be adjusted or modulated to meet varying load demands.

The turndown rate is an important consideration in HVAC system design and selection for several reasons:

- **Energy efficiency:** A low turndown rate allows the system to operate at lower capacities when the demand is low, which improves energy efficiency. By matching the system output closely to the actual load requirements, energy wastage is minimized, resulting in energy savings and reduced operating costs
- **Comfort control:** Systems with a low turndown rate can provide precise temperature control and maintain optimal comfort levels. They can respond quickly to changes in load demands and adjust their output accordingly, preventing temperature fluctuations and ensuring consistent comfort conditions
- **Load flexibility:** In applications where the load varies significantly, such as commercial buildings with fluctuating occupancy or variable process loads, a low turndown rate allows the system to adapt to these changes effectively. It ensures that the system can handle both high and low load conditions without compromising performance or efficiency

- **System longevity:** Systems with a low turndown rate tend to have a longer lifespan. Operating at lower capacities for extended periods reduces wear and tear on system components, resulting in reduced maintenance requirements and extended equipment life

Table 1: YMAE turndown rate

Model	YMAE0035	YMAE0070	YMAE0105	YMAE0140
Turndown rate	19%	9.5%	6.3%	4.7%

- **Control strategy:** Consider the control strategy of the heat pump system. Determine whether the minimum unit design requires a leader-follower configuration, or a central control system based on operational needs, to achieve effective control and modulation
- **Allowance for future expansion:** Consider future expansion and changes. It is advisable to reserve space in the minimum unit design to easily accommodate additional heat pump units when needed

It is important to balance cost-effectiveness, energy efficiency and system reliability in the minimum unit design. Consulting professional HVAC engineers or heat pump suppliers is advisable to receive customized recommendations based on specific project requirements and environmental conditions.

Water temperature difference, Delta T

When sizing an HVAC system, it's important to consider not only the target Delta T but also the temperature of the heating or cooling medium as it enters and leaves the system. If the temperature of the medium is too high or too low, it can cause damage to the system.

For example, if the temperature of the cooling medium entering an air-to-air heat pump is too high, it can cause the compressor to overheat and fail. Conversely, if the temperature of the cooling medium entering a water-to-air heat pump is too low, it can cause the system to freeze and stop working. Liquid temperature that is too high or too low is adverse for system stability and may cause reliability risks.

The YMAE liquid leaving temperature range is between 41°F and 68°F (5°C and 20°C) with water, -4°F and 68°F (-20°C and 20°C) with glycol in cooling, and 77°F and 140°F (25°C and 60°C) in heating. YMAE units monitor the cooling liquid temperature and heating liquid temperature status and have a protection trip in case any abnormalities are detected.

To avoid these problems, it's important to select an HVAC system that is correctly sized for the application and has a suitable Delta T range. With proper planning and selection, the system can provide many years of reliable operation.

Careful evaluation of the design Delta T and quantity of modules must be considered to ensure stable unit and system operation. If a large Delta T is required, then a low flow rate switch in the system yields better stability.

Design Delta T guidance

At maximum design flow for the heat exchanger, the Delta T is about 5°F (2.78°C). At minimum design flow, the Delta T is about 20°F (11.1°C).

The standard flow switch is a mechanical paddle type switch that is switched on or off in response to the flow or non-flow of a fluid. The paddle is displaced due to the force of fluid moving past it. In two-pipe units, there is one flow switch for each module, and the flow switch and entering strainer are factory-mounted inside the unit base enclosure. In four-pipe units there is one flow switch for each water loop, making a total of two for each module. The flow switch and strainer are shipped loose for field installation with a short section of water pipe that includes a threaded fitting and Victaulic-type water connections, including Victaulic clamp for the unit brazed plate heat exchanger (BPHX) to piping section. On both two-pipe and four-pipe units, the standard flow switch is suitable for flow above 51 gpm (193 Lpm).

The optional reduced flow switch is a mechanical paddle switch that operates and installs the same as the standard switch but is suitable for flow above 37 gpm (140 Lpm)

Table 2: Minimum and maximum flow rate for correct operation

Unit Models		Water Flow Range USgpm (Lpm)				Comments
		Cooling-Water Side		Heating-Water Side		
		Min.	Max.	Min.	Max.	
Four-Pipe	YMAE0035PJS	37 (140)	126 (477)	37 (140)	164 (621)	Two water loops
	YMAE0070PJS	74 (280)	252 (954)	74 (280)	327 (1,238)	
	YMAE0105PJS	111 (420)	378 (1,431)	111 (420)	492 (1,862)	
	YMAE0140PJS	148 (560)	503 (1,904)	148 (560)	656 (2,483)	
Two-Pipe	YMAE0035PJP	37 (140)	126 (477)	-	-	One water loop
	YMAE0070PJP	74 (280)	252 (954)	-	-	
	YMAE0105PJP	111 (420)	378 (1,431)	-	-	
	YMAE0140PJP	148 (560)	503 (1,904)	-	-	

Two-pipe and four-pipe selection

Suitability for application

A two-pipe HVAC system uses the same piping for both heating and cooling. The two-pipe system is less expensive to install and maintain. However, it may not be convenient if the application requires frequent changes between heating and cooling modes, or where there are multiple areas with different operating requirements.

A four-pipe HVAC system uses separate pipework for hot- and cold-water loops. These are suitable for applications with four-pipe terminals, or with separate heating and cooling terminals. The system allows multiple areas to be served independently with either cooling or heating as required. A four-pipe system may be more expensive to install because it has more components but offers much greater flexibility and can provide much higher overall building energy performance, which can result in significant operating cost savings. It can also heat the space and dehumidify the air at the same time.

Two-pipe and four-pipe combination system

It is possible to combine a YMAE four-pipe heat pump with a standard modular YMAE two-pipe in one system. This flexible combination offers better solutions for various cooling and heating loads. A maximum of 32 YMAE modules, either two-pipe, four-pipe, or a combination, can be connected electronically to operate as a single unit through the modular control capability included as standard on every unit. This offers significant flexibility to the system designer.

Up to four modules are available as a factory-packaged modular array, with all units in the array either two-pipe or four-pipe units. The array includes single-point power connection (SPC) as standard with a 65 kA SCWR circuit breaker mounted within the unit frame. It is possible to connect up to two arrays, or eight modules, with an optional single-point terminal block enclosure, which is field-mounted adjacent to the heat pumps on a separate base, and field wired to each array single point connection circuit breaker. When selecting either a two-pipe or four-pipe heat pump, prioritize the peak heating demand. Use this to determine the capacity required, and as result, the quantity of modules.

On four-pipe units, the unit control logic auto-balances cooling and heating loads within the unit frame, allowing independent and dynamic control of both hot and chilled water temperatures to meet customers' requirements. Excess heat is rejected, or required heat is captured, as necessary using the air-side heat exchanger coils.

In an application with much higher peak heating than cooling demand, it is possible to use a combination of both two-pipe and four-pipe heat pumps, reducing cost and complexity of the installed unit and piping header.

The following is an example of a combined two-pipe and four-pipe application:
Peak heating load is 6400MBH at -5°F (-20.5°C), which requires approximately 30 modules to meet the heating load.
Peak cooling load is 325T at 90°F (32.2°C), which requires approximately 10 modules.

Peak simultaneous load is 2,500 MBH, which requires approximately eight four-pipe modules.

For this application, lay out 10 four-pipe modules and 20 two-pipe modules, then connect the piping header to the heating side of the four-pipe modules and to the two-pipe modules, so that the cooling side only goes to the chilled water loop. In peak summer, the 10 four-pipe modules would run as chillers because there is no heating load. In the shoulder months, the four-pipe modules would operate in simultaneous mode, potentially having excess capacity. In winter, there is no cooling load so the four-pipe modules operate to heat only in conjunction with two-pipe modules.

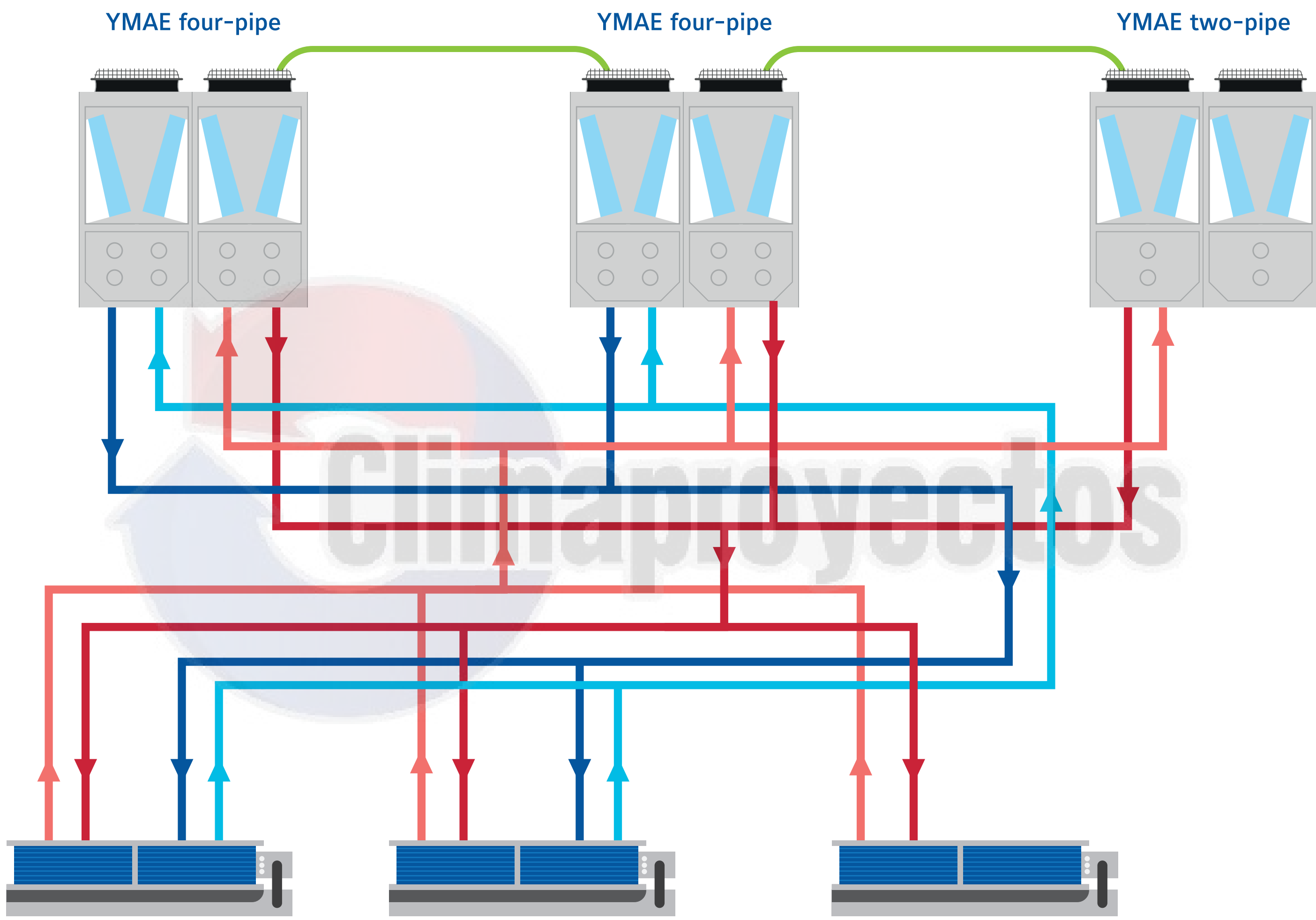


Figure 8: Combined two-pipe and four-pipe application

Layout guideline

To achieve optimum performance and trouble-free service, it is essential that the proposed installation site meets the location and space requirements for the model being installed.

The clearances recommended are nominal for the safe and efficient operation and maintenance of the unit and power and control panels. Local health and safety regulations, or practical considerations for service replacement of large components, may require larger clearances than those given in this manual.

Outdoor installations

The user can install the units at ground level on a suitable, level foundation easily capable of supporting the weight of the unit, or on a suitable rooftop location. In both cases an adequate supply of air is required. Avoid locations where the sound output and air discharge from the unit could cause disturbances.

The location must be away from boiler flues and other sources of airborne chemicals that could attack the condenser coils and steel parts of the unit.

For ground level locations, install the unit on a suitable flat and level concrete base that extends to fully support the two side channels of the unit base frame. A one-piece concrete slab, with footings extending below the frost line is recommended. To avoid noise and vibration transmission, do not secure the unit to the building foundation. It is advisable to use optional neoprene isolators, at the very least.

On rooftop locations, choose a place with adequate structural strength to safely support the entire operating weight of the unit and service personnel. The user can mount the unit on a concrete slab, similar to ground floor locations, or on steel channels of suitable strength.

Space the channels with the same centers as the unit side and front base rails. This allows the user to install vibration isolators if required. Isolators are recommended for rooftop locations. Ensure that the place of installation and operation can support the weight of the unit and any extra operation and maintenance weights that may occur.

Location clearances

Adequate clearances around the units are required for the unrestricted airflow for the air-cooled condenser coils and to prevent re-circulation of warm discharge air back onto the coils. If clearances given are not maintained, airflow restriction or re-circulation causes a loss of unit performance, an increase in power consumption and may cause the unit to malfunction. Consider the possibility of down drafts, caused by adjacent buildings, which may cause re-circulation or uneven unit airflow and other potential obstructions, such as snow in low temperatures. The installing contractor must include ventilation and drainage in the plumbing.

Figure 9: Recommended clearance for single module

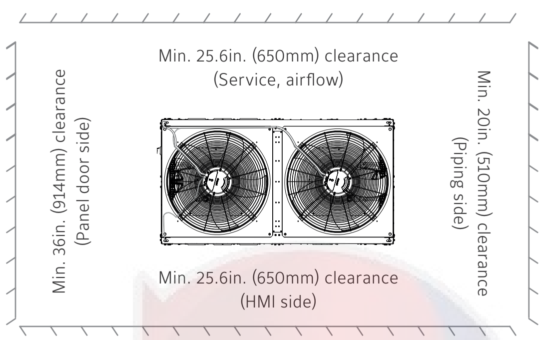


Figure 10: Modular array clearance

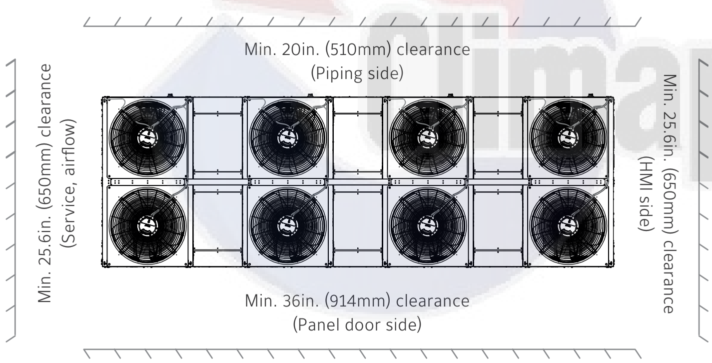
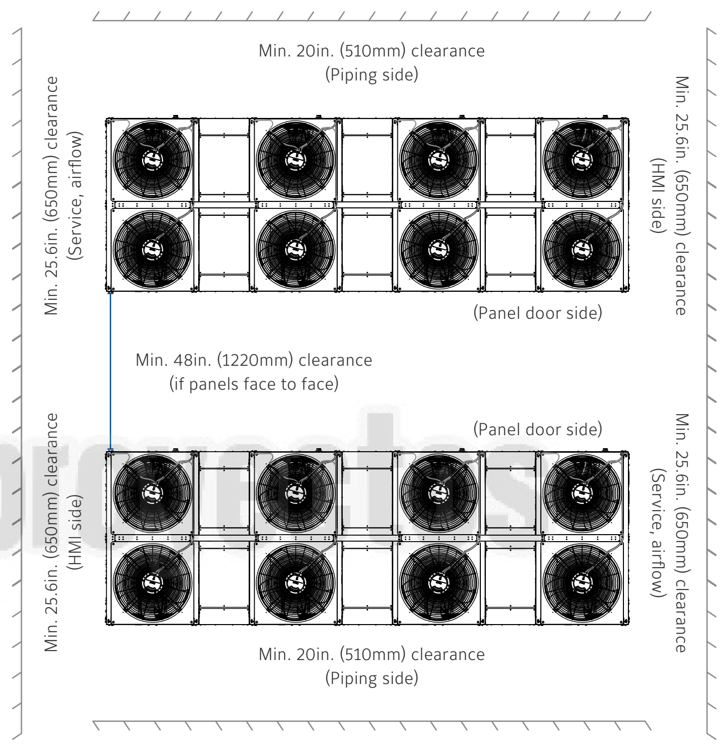


Figure 11: Modular array panel face-to-face clearance



Recommended minimum clearances:

- Control panel to wall: 36 in.
- If panels face each other, space between panels: 48 in.
- HMI side to wall: 25.6 in.
- Duct side to wall: 20 in.
- Between adjacent devices: 25.6 in.
- Top: no obstructions allowed
- Adjacent walls must not exceed the height of one unit

The water system

Water system configurations

System structure

- **Primary pumping system:** The heat pump and the fan coil unit share a set of circulating water pumps
- **Secondary pumping system:** The heat pump and the fan coil unit are equipped with separate circulating water pumps

Flow variation of fan coil units

- **Constant flow system:** The circulating water flow on the fan coil side is maintained at a constant value. If the end of the water system has a manual water valve, an electric three-way regulating valve, or three-way solenoid valve, it is a constant flow water system
- **Variable flow system:** The circulating water quantity at the fan coil side changes with the change in cooling capacity. If the end of the water system has an electric two-way valve, an electromagnetic two-pass valve, or a dynamic balanced electric regulator valve, it is a variable flow water system

Water system layout

When a centralized controller manages multiple modules, these modules create one system. Each HMI controller can control up to 32 modules. The layout of the water system ensures all modules in the system have flow requirements met, regardless of the capacity of the unit. If there is insufficient water flow, various unit protections are triggered, which can affect normal operation of the system

Note: To ensure the correct water flow in the system, the water pump needs to be considered:

- Each modular array has a passive output signal, contact capacity 1 A/ 250 V, on only the first module, which controls the water pump. At startup, the water pump starts first, and the modular array will perform the startup process 20 seconds later. When the heat pump shuts down, the modular array shuts down first, and the pump stops about 90 seconds later
- The water pump must be interlocked with the heat pump

Figure 12: Simplified diagram of typical water system layouts

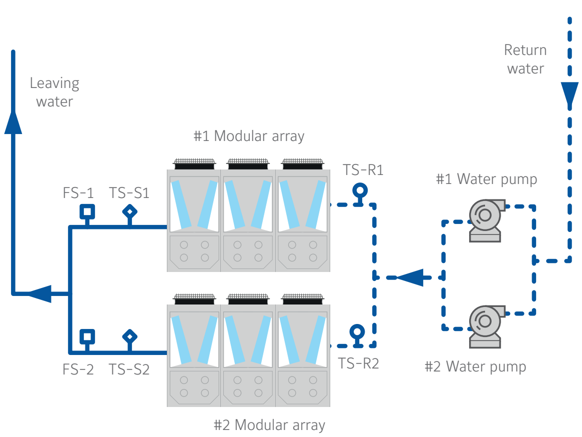


Diagram A: Simplified schematic diagram of series arrangement

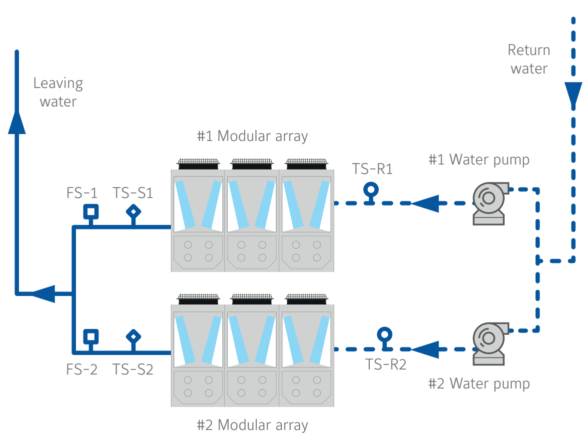


Diagram B: Simplified schematic diagram of parallel arrangement

Primary pump, constant flow system

The primary pump, constant flow system is a widely used air conditioning system. There are two circuit arrangements for this system: series or parallel.

Series arrangement:

- At startup, all the water pumps start, not including the standby pump; otherwise, it leads to insufficient water flow in the unit
- All pumps can only stop when all the modules are shut down.
- Check valves are installed at each pump outlet
- Simple pipework

Parallel arrangement:

- A water pump is installed in the piping of each module, and a check valve is installed at each pump outlet
- When a unit starts, the water pump on the same circuit is opened. If the unit is turned off, the water pump on the same circuit is turned off. Pumps on parallel circuits do not interact or interfere with adjacent circuit operation

Primary pump, variable flow system

Series and parallel arrangements are both also applicable in the primary pump, variable flow system. Variable flow systems offer energy savings by reducing the pump speed and water volume at partial load

Series arrangement:

- At startup all water pumps start, not including the standby pump; otherwise, it leads to insufficient water flow in the module
- All pumps can only stop when all modules are shut down
- Check valves are installed at each pump outlet

Parallel arrangement:

- A water pump is installed in the piping of each module, and a check valve is installed at each pump outlet
- When a unit starts, the water pump on the same circuit is opened. If the unit is turned off, the water pump on the same circuit is turned off. Pumps on parallel circuits do not interact or interfere with adjacent circuit operation
- This arrangement can achieve energy-saving operation due to partial load operation

Regardless of the arrangement, with variable flow systems the outlet side flow changes with unit loading and unloading. To ensure that the water flow across the heat pump is unchanged, the pumping system must also perform a dynamic hydraulic balance.

Constant flow/variable flow, secondary pump system

In constant or variable flow systems with a secondary pump, the end secondary pump side is constant or variable flow, while the primary pump side is always circulating at constant flow.

This kind of system is not widely used. When implemented, use a parallel arrangement for the main equipment room under partial load operation. Some pumps can be manually shut down along with the module to achieve energy saving operation. The building load side of the secondary water system cannot adopt variable frequency pump.

Benefits of a VPF system compared to a constant primary-secondary system

- Low installation cost: Both systems have similar arrangements, but secondary pumps are substituted in a VPF system for higher capacity VFD pumps, which are only used in a primary circuit to regulate flow in the entire system. Other accessories like the flow meter, bypass control valve, DP sensor, and heat pump isolation valve are an additional cost in VPF system but roughly 5% of the overall cost can be saved in initial investment
- High energy saving: VPF systems save energy compared with constant flow pumping systems during part load operation because water flow is reduced and less pump energy is required. Also, less pumping power is required as the overall system head loss is reduced. Around 15% net saving in pumping power is possible with VPF systems. In addition, with reduced water flow during part load operation, less compressor energy is required. So, an overall operating cost saving of between 20% and 30% is possible

- Reduced plant room footprint: Because the VPF system does not have a secondary pumping system, this saves on installation space
- Better response to low Delta T syndrome: If a system has Low Delta T Syndrome, the system pumps more water than is required, which wastes energy. This can occur because of several different potential chilled water or airside issues. To compensate for this, additional pumps have to be turned on in a constant primary flow system while the same can be achieved by speeding up the already-running pump for a VPF system

Designing a VPF bypass

- Size for minimum flow through one module
- Bypass valve must be the normally open type
- Valve head ratings must be higher than pump dead head
- Linear characteristic: valve position % equals flow %
- Fast actuator
- Valve control range: 100:1
- The flow meter controls the bypass to maintain modular minimum flow
- In accordance with the manufacturer's instructions

Challenges

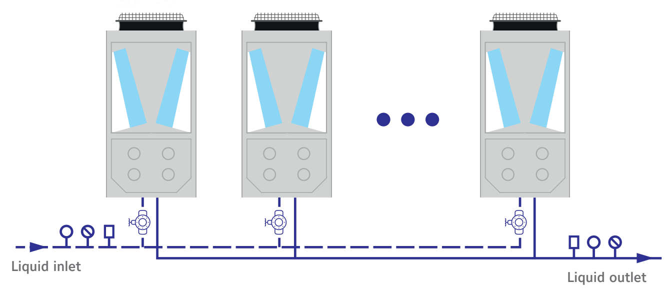
- Avoid using VPF systems where chilled water temperature is critical, such as a clean room or process applications
- Cannot use in systems where only three-way valves are used
- Do not use VPF if it is unlikely that the operator will run the plant as designed
- The system must be able maintain a minimum flow rate through the heat pump, have quick unloading cooling capacity, and have condenser head pressure control
- Requires a more robust, complex and calibrated control system
- Requires coordinated controls of heat pumps, isolation valves and water pumps in sequencing

Pipework connection

The following piping recommendations are intended to ensure satisfactory operation of the unit. Failure to follow these recommendations could cause damage to the unit, or loss of performance, and may invalidate the warranty:

- A flow switch is included as standard on each module. It is factory-wired and installed in the extension pipe between the heat exchanger outlet and the edge of the heat pump (two-pipe) or field-wired and installed in the included, externally mounted pipe at the outlet of the heat exchanger (four-pipe)
- Pipework and fittings must be externally supported to prevent any loading on the heat exchangers. Flexible connections are recommended, which also minimizes transmission of vibrations to the building. Flexible connections must be used if the unit is mounted on anti-vibration mounts because some movement of the unit is expected in normal operation
- Pipework and fittings immediately next to the heat exchangers must include provision for removal to enable cleaning before operation, and to facilitate visual inspection of the exchanger nozzles
- Each heat exchanger must be protected by a strainer, preferably of 20 mesh, fitted as close as possible to the liquid inlet connection, and provided with a means of local isolation to enable regular strainer cleaning. A 20-mesh wye-strainer is provided as standard to provide additional protection at the heat exchanger inlet
- The heat exchangers must not be exposed to flushing velocities or debris released during flushing. It is recommended that a suitably sized bypass and valve arrangement be installed to allow flushing of the pipework system. The bypass can be used during maintenance to isolate the heat exchangers without disrupting flow to other units
- It is recommended to provide thermometer and pressure gauge connections on the inlet and outlet connections of each module piping connection
- Provide drain and air vent connections at all low and high points in the pipework to permit drainage of the system and to vent any air in the pipes
- Protect liquid systems at risk of freezing due to low ambient temperatures by using insulation and heater tape or a suitable glycol solution. The liquid pumps must also be managed to circulate liquid when the ambient temperature approaches freezing point. YMAE standard control logic includes an optimized, temperature-dependent pump control sequence. A pump controlled by an external system is also acceptable
- On two-pipe units, factory-installed insulation and heater tape is provided for all pipework and heat exchangers inside the unit frame. On four-pipe units, the external, field-mounted pipe connection (with flow switch) and inlet strainer must be insulated by others
- When multiple modules are combined, the connected water pipes must be designed to provide balanced water flow to each module. This can be achieved with a properly sized, reverse return type as detailed in the following figure

Figure 13: Reverse return

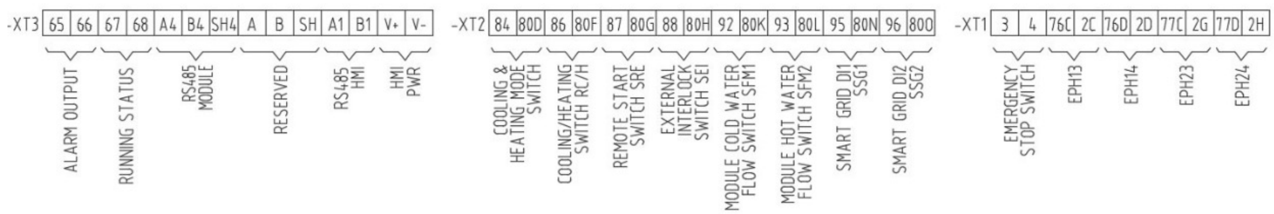


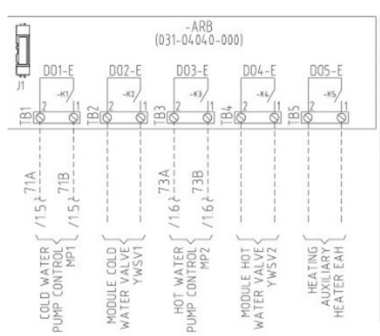
- Shut-off valves, thermometer and pressure gauges should be installed on the inlet and outlet pipes of individual modules to regulate the water flow and to shut off the water flow during maintenance

When multiple modules are combined, it is recommended that each module inlet be provided with an isolation valve, to stop water flow through the module when it cycles off. The YMAE standard control logic can control this valve. Different valves have different times from closing to fully opening and can be set by the HMI according to the selected valve opening time: 0-120 seconds. The valve receives on-off signals. The valve must be provided by others.

- Selecting unit isolation valves: variable flow system
- A butterfly-type valve is recommended to provide the largest flow as quickly as possible when opening
- Valve pressure rating must be greater than pump dead head
- Linear characteristic: valve position % equals flow %
- The unit can be provided with an optional water pump, which is controlled by the unit automatically. If the unit is not equipped with a factory water pump, the unit provides a signal by dry contact for water pump control: dry contact capacity 1 A at 250 VAC. The water pump must be linked to the control signal on the leader module to use this feature. It is recommended that a backup pump is installed on site to prevent the failure of the commonly used pump from affecting the operation of the unit. When the factory dual pump kit option is equipped, run hours will be equalized between the primary and standby pump. When external dual pumps are used, only a run signal is provided and run hour equalization should be controlled internally by the pump
- Water pump outlet must include a check valve. If two or more pumps are connected in parallel in a water circuit, the outlet of each pump needs to be equipped with a check valve. The purpose of installing check valves is to prevent water bypassing from unused pumps or faulty pumps
- It is recommended to install a water filter of no less than 30 mesh per inch on the inlet pipe of the external water pump to ensure reliable operation of the water pump
- Drain connections should be provided at all low points in the piping system to permit complete drainage of the cooler and system water piping during low ambient temperature periods when system operation is not required for an extended duration, or for service

Field Wiring and check before starting up





ABBR	DESCRIPTION	ABBR	DESCRIPTION	ABBR	DESCRIPTION	ABBR	DESCRIPTION
YWSV2	MODULE HOT WATER VALVE	SFM2	MODULE H-WATER SF	FU	FUSE	BLST2	LEAVING SYS. H-WATER TEMP
YWSV1	MODULE COLD WATER VALVE	SFM1	MODULE C-WATER SF	FLP*2	HEATING LOW PRESS SWITCH	BLST1	LEAVING SYS. C-WATER TEMP
YOSV	OIL RETURN SOL VALVE	SEI	EXTERNAL INTERLOCK SWITCH	FLP*1	COOLING LOW PRESS SWITCH	BLMT2	LEAVING MODULE H-WATER TEMP
YMSV	MODE SOL VALVE	SC&H	COOLING & HEATING MODE SWITCH	FHP	HIGH PRESS SWITCH	BLMT1	LEAVING MODULE C-WATER TEMP
YMEV	MAIN EEV	SC/H	COOLING/HEATING MODE SWITCH	EXT	EXTERNAL PART	BPHE	BRAZED PLATE HEAT EXCHANGER
YLISV	LIQUID INJECT SOL VALVE	SC-EQ	BACNET GATEWAY BD	EPH24	OUT-PIPE HEATER OF H-WATER HYDRO KIT	BEMT2	ENTER MODULE H-WATER TEMP
YESV	EVI SOL VALVE	QCB	CIRCUIT BREAKER	EPH14	OUT-PIPE HEATER OF C-WATER HYDRO KIT	BEMT1	ENTER MODULE C-WATER TEMP
YEEV	EVI EEV	MRF	REFRIGERANT FAN	EPH23	IN-PIPE HEATER OF H-WATER HYDRO KIT	BECOT	ECO OUTLET TEMP
YDSV	DEROST SOL VALVE	MP2	H-WATER PUMP	EPH13	IN-PIPE HEATER OF C-WATER HYDRO KIT	BECIT	ECO INLET TEMP
YCSV	COIL BRANCH SOL VALVE	MP1	C-WATER PUMP	EPH21/22	IN/OUT-PIPE HEATER OF H-WATER PHE	BDT	DISCHARGE TEMP
YASV	AC BPHE SOL VALVE	MF	EC FAN	EPH11/12	IN/OUT-PIPE HEATER OF C-WATER PHE	BAMB	AMBIENT TEMP
XT	TERMINAL BLOCK	MDF	DRIVER COOLING FAN	EEH2	HOT WATER PHE HEATER	BACDT	AIR COIL DEFROST TEMP
SRS	REMOTE START SWITCH	MC	COMPR MOTOR	EEH1	COLD WATER PHE HEATER	BAIT	ACCUMULATOR INLET TEMP
SSG2	SMART GRID READY 2	LR	REACTOR	ECH	CRANK CASE HEATER	AF	FILTER/FILTER BOARD
SSG1	SMART GRID READY 1	KRS	RUNNING STATUS RELAY	BSP	SUCTION PRESS TRANSDUCER	ARB	RELAY BOARD
-	-	KPH	PUMP KIT HEATER RELAY	BRLD	REFRIGERANT LEAK DETECTOR	ADB	DRIVER BOARD
-	-	KAL	ALARM OUTPUT RELAY	BDP	DISCHARGE PRESS TRANSDUCER	AMB	MAIN CONTROL BOARD
ABBR	DESCRIPTION	ABBR	DESCRIPTION	ABBR	DESCRIPTION	ABBR	DESCRIPTION

- Unit power should be on to provide the freeze protection function unless the liquid systems have been drained. When liquid systems have been drained, unit power should be left switched off to avoid damage by auto starting freeze protection when liquid is not present
- Install an auto-feed valve for closed-type water systems, without an open expansion tank, to prevent unit damage from operation without sufficient water volume in the system. Set the outlet water pressure of the auto-supply valve 4.35 psi (0.3 bar) higher than the static pressure of the system. Ensure the value set is lower than the supplementing water pressure, that is the source of the water supplementing, or it would not conduct normal water supplement. The auto-feed valve is usually installed at the return water line of the system. Heat isolation measures must be implemented on the water supplement pipeline and water supply valve to protect against freezing in low temperatures
- Install a buffer tank in the water system to prevent frequent start-ups of the unit. For buffer tank selection, see loop volume recommendations
- The terminal device in the water system must be equipped by the customer with a three-way valve or a bypass valve to make the water system circulate fluently during the period when the anti-freezing water pump is operating in low temperatures
- When the unit is a modular array, the total inlet and outlet pipes of the water system must each have a location to install a temperature sensor for the inlet and outlet water temperature sensors of the system. If the water system requires the installation of auxiliary electric heating, the water system's total outlet water temperature sensor must be installed after the auxiliary electric heating
- The flow range of the unit must be controlled between 70% to 130% of the rated flow.
  Standard pipework connections are Victaulic connections. The inlet and outlet cooler connection sizes are 2-1/2 in. Use the left side piping for the cold-water connection and the right side (four-pipe model) for the hot-water connection
- The inlet minimal pressure of the water pump reaches 20 kPa to avoid cavitation noise and damage to the water pump

Figure 15: Water connection diagram

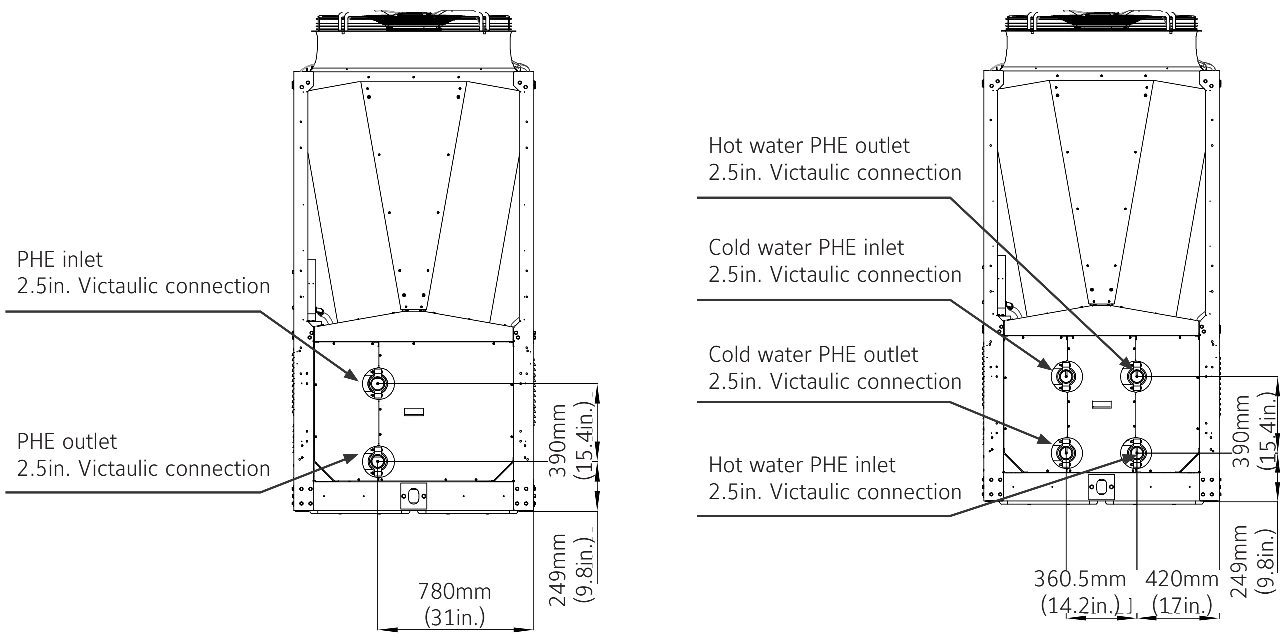


Figure 16: Installation diagram of fixed water flow system, modular array

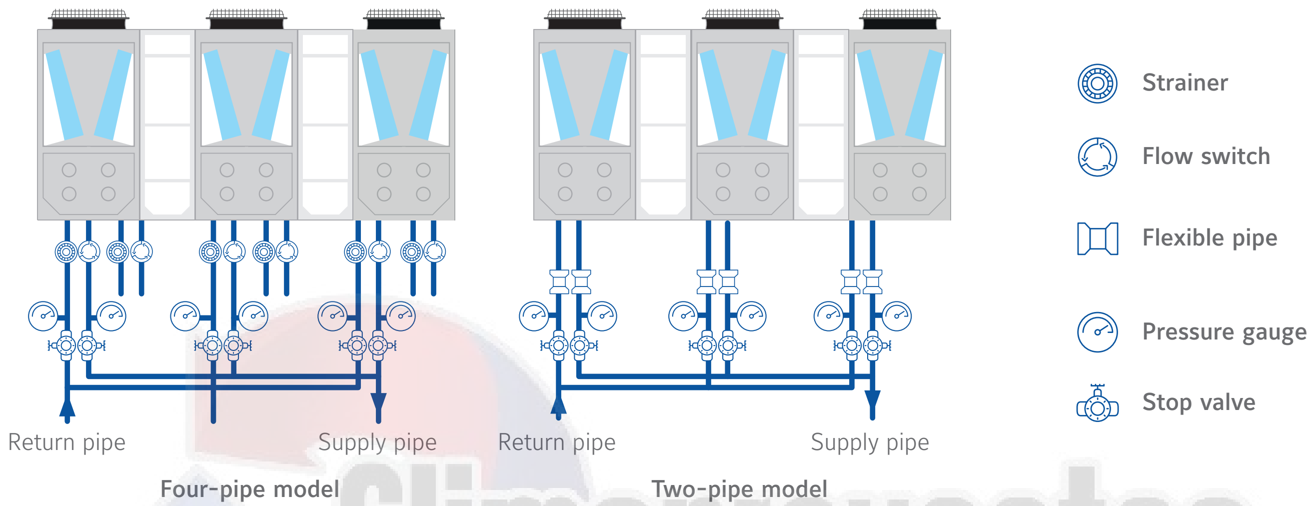
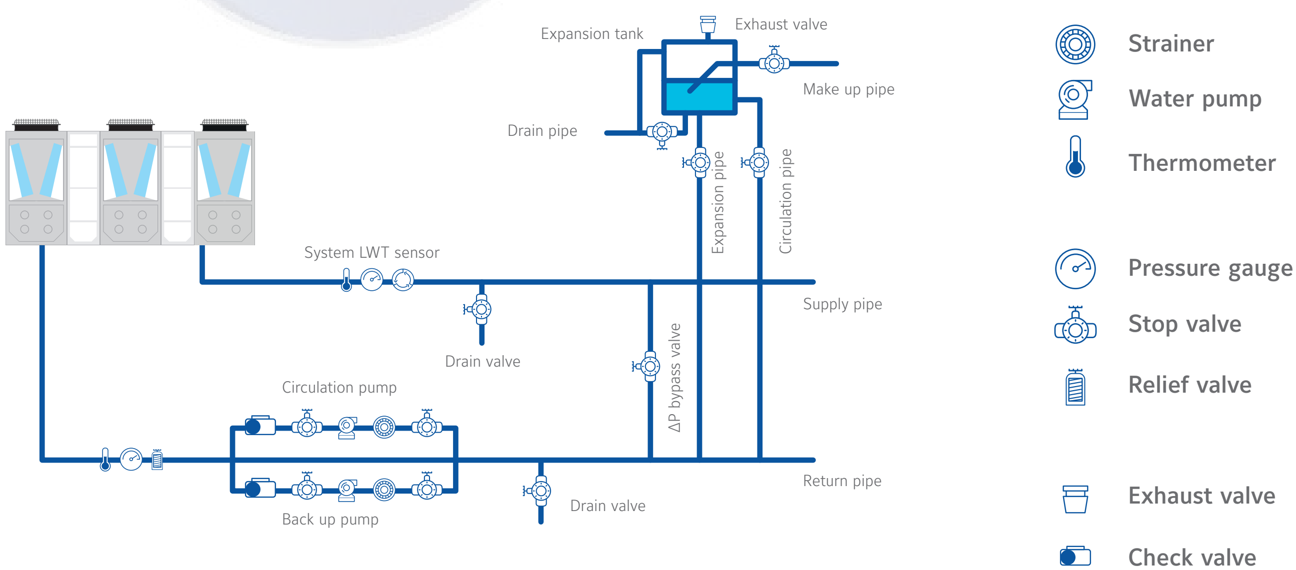


Figure 17: Recommended piping for fixed flow water system

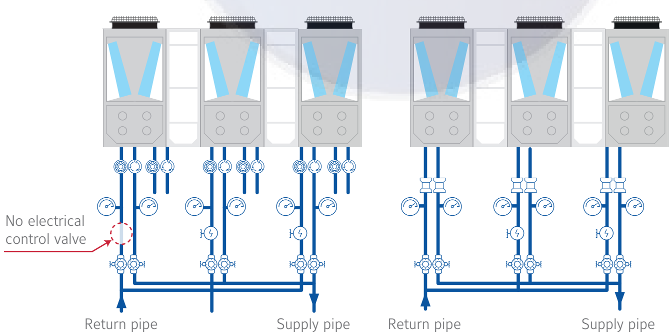


Note:

- If using a constant flow system, do not use isolation valves to isolate units that are not running. Keep flow through all units
- System LWT sensor on head supply pipe for LWT control
- Circulation pump and back up pump on the return pipe
- Strainer on the inlet of pump to avoid impurities
- Delta P bypass valve to keep water flowing when all indoor FCUs are closed
- Expansion tank to ensure there is enough water capacity in the water system
- Drain valve for draining water for maintenance or inactivity

The following figure is the water connection diagram on one side. The water connections for the cold and hot water systems of the air conditioner must adhere to the following diagram:

Figure 18: Recommended modular array piping for variable flow system



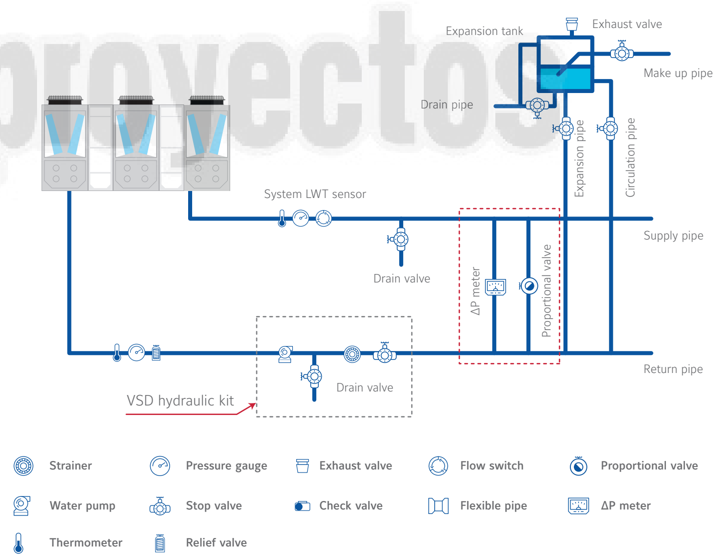
Note:

- Additional electrical control valve for each follower module
- Do not set the electrical control valve on the leader module
- Cold side piping is shown; the hot side is identical

Variable flow with hydraulic kit option

- The VSD pump provided with the hydraulic kit auto-adjusts the pump output speed according to the pressure difference between the pump inlet and outlet
- The Delta P meter detects the building-side resistance
- A proportional valve controls the user side resistance to a preset target based on the Delta P meter detection
- The VSD pump has a constant Delta P control
- Other VSD pump control based on specific water system design. Contact your local Johnson Controls sales office to consult on alternate configurations

Figure 19: Variable flow system with factory hydraulic kit option

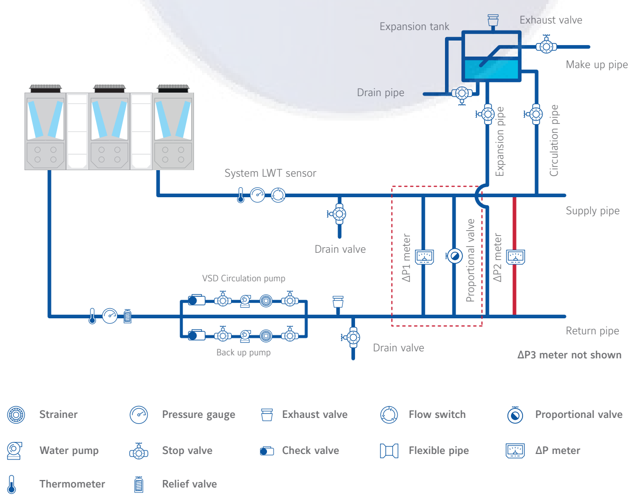


Variable flow without hydraulic kit option

Figure 20 shows the recommended and alternate control points for pump control on systems without a factory hydraulic kit option.

- The Delta P meter detects the user side resistance
- A proportional valve controls the user side resistance to a preset target based on the Delta P meter detection (shown in red box)
- The Delta P meter and proportional valve are located near the first terminal device, near the fan coil, or the outlet of the mechanical/pumping space
- The VSD pump has a constant Delta P control
- The VSD pump is controlled to constant pressure differential at Delta P2, which is recommended. Delta P2 is located between the water supply/return pipe near the exit of the mechanical system, close to the first terminal device on building load side

Figure 20: Variable primary flow control points



Alternate pump control methods

There are alternate control points possible for a variable primary system. See Figure 19 in the previous section.

- Delta P1, between the modular array supply/return pipe. This is recommended on less stable water systems with low volume or rapid load changes and may result in short cycling of the heat pump
- Delta P3 is the most unfavorable circuit for customer terminal loop because it has the biggest pressure drop in the piping system. This is not recommended due to its slow response
- Other VSD pump control based on specific water system design

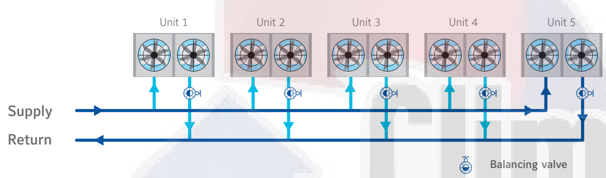
Piping

Closed-loop systems can be further classified as direct return or reverse return.

Direct return

The direct return system allows piping to be run in the most direct path to optimize piping costs. The length of the water circuit through the supply and return piping to each unit is different in direct return piping. Units close to the pump receive a greater flow rate than those further away unless balancing is accomplished.

Figure 21: Direct return

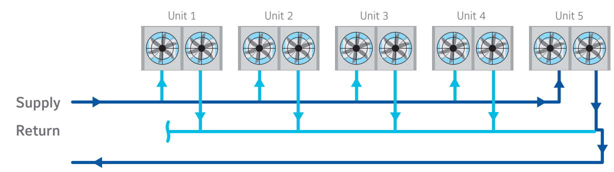


- Water enters Unit 1 from supply
- Water leaves Unit 1 and returns directly to source
- The first unit supplied is the first returned
- Unequal circuit pressure drops result
- Circuit pressure drop through
- Unit 1 < Unit 2 < Unit 3 < Unit 4 < Unit 5
- Balancing valves are a necessity

Reverse return

The reverse return system is piped so that the length of the water circuit through the supply and return piping to each fan coil or air handler is essentially the same. As a result, pressure drops are basically equal.

Figure 22: Reverse return



- Water leaves Unit-1 and goes all the way around in returning to source
- The first unit supplied is the last returned
- Circuit pressure drop through
- Unit 1 = Unit 2 = Unit 3 = Unit 4 = Unit 5

Balancing valves may be eliminated Reverse return has greater pipe lengths and cost. However, the cost of adding a balancing valve for each unit using a direct return system could offset the additional costs of the added reverse return piping.

Note: Reverse return piping layout is strongly recommended to ensure equal flow across all units, preventing nuisance trips and reducing risk of freeze damage.

Loop volume recommendations

Buffer water tank

A buffer tank is not mandatory in the water system but it can help improve the system operating stability, stabilize the water temperature and provide a buffer for temperature variation due to unit sequencing and defrost. If the system water capacity is too low, use a buffer tank to reach the minimum value shown in Table 2.

In the following cases, the system must include buffer tanks to prevent frequent start and stop cycling of the unit, which can cause damage to the compressors and increase operating costs:

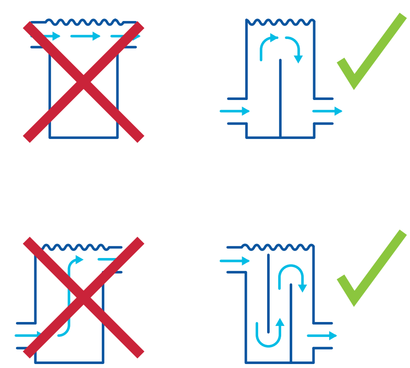
- The water system volume is below the minimum required volume
- The application requires high accuracy temperature control
- The load between the unit and the customer terminal does not match, for example if the customer terminal loading is less than the minimum turndown rate (20%) of the unit

Ensure the volume of the buffer tank is not less than the minimum water capacity minus the pipeline water capacity minus the end water capacity. The minimum volume is 6.06 gal/ton (6.5 L/kW) and the recommended volume is between 7 gal/ton (7.5 L/kW) and 11.18gal/ton (12 L/kW).

Note: If the site's requirement of water temperature fluctuation is specific, contact your local Johnson Controls office.

To avoid this, a buffer water tank should be applied, or the diameter of main water pipe should be enlarged to meet the recommended range in the Table 2. See the following figure for the correct installation method of the buffer tank.

Figure 23: Buffer water tank installation



Expansion tank (pot)

The system design must include an expansion tank to help manage the following potential issues:

- To help with water volume changes in the system, for example from thermal expansion and contraction caused by the water temperature change
- To prevent the water system from freezing and cracking in low temperatures
- To prevent unstable pressure at the inlet of the pump
- To replenish water in the system and outlets

Connect the expansion tank piping to the pump inlet before the pressure gauge on the water return pipeline. Ensure it is between 59.06 in. (1.5 m) and 118.1 in. (3 m) from the pressure gauge.

Note: Consider using antifreeze for insulation in low temperatures.

Freeze protection

Intelligent anti-freezing

With the temperature sensor for monitoring the temperature of entering and leaving water, the YMAE unit shuts down to avoid the water-side heat exchanger being frozen when the monitored water temperature is lower than the anti-freezing setpoint. It resumes after the temperature rises above the anti-freezing setpoint again.

Ambient Temperature		Freeze Protection Entry Conditions
32°F to 37.4°F	0°C to 3°C	Water pump has been OFF for 60 min
26.6°F to 32°F	-3°C to 0°C	Water pump has been OFF for 30 min, or either system LWT or EWT ≤ 50°F (10°C)
14°F to 26.6°F	-10°C to -3°C	Water pump has been OFF for 15 min, or either system LWT or EWT ≤ 53.6°F (12°C)
Less than 14°F	Less than -10°C	Water pump has been OFF for 8 min, or either system LWT or EWT ≤ 53.6°F (12°C)
If there is fault with the sensor		Water pump has been OFF for 15 min, or either system LWT or EWT ≤ 53.6°F (12°C)

LWT = leaving water temperature
EWT = entering water temperature

- To enter freeze protection, both LWT and EWT are monitored. If either parameter meets the control logic, the unit enters freeze protection mode
- To exit freeze protection, the priority is to check the system EWT. If EWT parameters meet the control logic, the unit exits freeze protection. If there is an EWT sensor fault, the system LWT is checked

Note: The unit controls the pump during freeze protection mode.

Freeze protection actions and exit criteria

Freeze protection control includes a cooling loop and heating loop:

- Heating water loop: The unit is off, or the unit is operating in cooling only mode and the heating loop is on standby
- Cooling water loop: The unit is off, or the unit is operating in heating only mode and the cooling loop is on standby.
- Glycol mode does not have this control logic

Cooling water loop:

- If the system LWT (EWT) is ≥ 55.4°F (13°C) after water pump has been running for 90 s, freeze protection stops
- If the system LWT (EWT) is <55.4°F (13°C) after water pump has been running for 90 s, the water pump keeps running until the system LWT (EWT) is >59°F (15°C), which stops freeze protection

Note: The maximum freeze protection operation duration is 120 minutes.

Heating water loop:

- If the system LWT (EWT) is ≥55.4°F (13°C) after water pump has been running for 90 seconds, freeze protection stops
- If the system LWT (EWT) is< 55.4°F (13°C) after water pump has been running for 90 seconds, the water pump keeps running until the system LWT (EWT) is <62.6°F (17°C), which stops freeze protection

Note: The maximum freeze protection operation duration is 60 minutes.

Unit freeze protection design considerations

It is necessary to drain water from the unit's water circuit when the ambient temperature is low or if it has not been in use for 90 days. Otherwise, parts of the water system, including the heat exchanger and pump, have a risk of freezing at low temperature. After draining the water, the unit needs to be powered off to avoid damaging the pump, the compressor, and other parts when the unit automatically starts the anti-freezing operation.

When the ambient temperature is lower than 32°F (0°C), the unit can freeze. If the user does not drain water from the unit or if the unit still needs to run when the ambient temperature is lower than 32°F (0°C), do not cut the power supply of the unit, do not close the water system valve, and ensure that the water pump can be controlled by the heat pump to enter anti-freeze operation if necessary. Ensure that the water system can circulate smoothly during the anti-freeze operation, so that the unit can automatically enter the anti-freeze operation when needed.

To ensure the reliability of anti-freeze operation throughout the year, add glycol antifreeze to the chilled water system. When there is a year-round chilled water demand, that is cooling below 32°F 0°C or cooling and heating at the same time, or low temperature chilled water demand, that is chilled water temperature below 41°F (5°C), the chilled water system needs to add the appropriate concentration of glycol antifreeze. The antifreeze concentration and solution freezing point needs to be reliable during the lowest possible temperatures, which is affected by the ambient temperature and water temperature. Confirm the specific requirements of the antifreeze solution and the inhibitor with the pump supplier if the pump is prepared by customers.

BMS control

The YMAE building management controls use the RS-485 standard, including BACnet MS/TP, Modbus RTU or N2 connectivity for communication with virtually any building management system. This advanced, embedded control capability also allows multiple heat pumps to be connected and monitored through a single controller. Each unit features a touchscreen display that has an easy-to-use, web-style interface and intuitive navigation for easy access to operational data. Information can be displayed in multiple languages and setup is very easy.

To simplify installation and setup, the SC-EQ Communication Board automatically determines the building automated system (BAS) protocol, Baud rate, and the model of the connected water pump or rooftop unit. The only user setting is the MAC address for the SC-EQ on the BAS network.

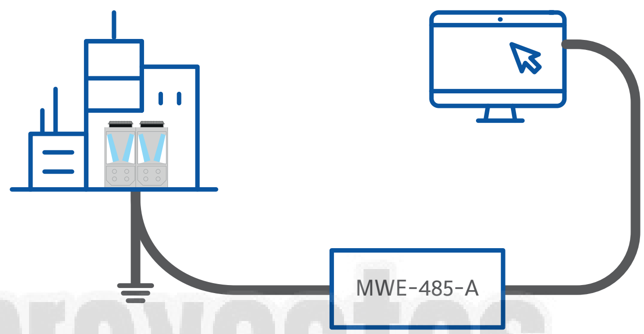
Figure 24: MAC address and BAS connection port

Cabling requirements

The BAS port on SC-EQ board in the electrical cabinet of the leader module unit is the communication interface between the unit and the BMS. The customer needs a RS-232/RS-485 converter between the SC-EQ BAS port and the customer BAS. The communication line has polarity: A is connected to converter A (or +), B is connected to converter B (or -). To avoid malfunction, ensure it is connected correctly.

For cabling distance within 100 m, use 2 × 0.75 mm^2 shielded twisted pair cable. For cabling between 100 m to 500 m, use 2 × 1.0 mm^2 shielded twisted-pair cable.

Figure 25: Converter between SC-EQ BAS port and customer BAS



BMS command instructions

The BAS can request the unit to switch between modes a minimum of every 12 minutes. The unit must operate for a minimum of six minutes before it can be switched back to the previous mode. When switching modes, there needs to be time between stopping one mode and starting another so that system temperatures can moderate enough for the unit to start in the new mode of operation. If the BAS rapidly switches the unit from heating to cooling, or visa-versa, the extreme temperature from the previous mode may cause the unit operational issues in the newly commanded mode.

Modbus and BACnet

For the most recent points lists for the two-pipe and four-pipe units, refer to the YMAE Points List Two-Pipe Equipment and YMAE Points List Four-Pipe Equipment on the Chillers Knowledge Exchange.

YORK®

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