

**Application Note 2037:
QAHV CO2 HOT WATER HEAT PUMP
Product Introduction
& Application Overview**

**2025 New Three Tier Offering:
HEAT2O CORE, KIT, CONNECT (SKID)**

Table of Contents

WHAT IS QAHV?.....	4
GENERAL SYSTEM APPLICATION & RATING DATA	5
General Application Considerations / Target Applications	5
Market Drivers – Carbon Reduction, Electrification, and Global Warming Reduction	5
System Operating Temperatures, Rating Charts, and Flow Rate Ranges	6
APPLICATION DETAILS & DESIGN CONSIDERATIONS	10
Primary Heat Exchanger Loop & QAHV Direct Potable Water Connection Concerns.....	10
Primary Separation Loop Expansion Tank Considerations & Buffer Volume.	11
Storage Tank & Swing Tank Considerations.....	12
Tank Options Available & Minimum Storage.....	13
2025 New 3 Tier Offering.....	15
HEAT2O CORE	15
HEAT2O KIT	15
HEAT2O CONNECT (SKID).....	15
New 3 Tier Summary Comparison:.....	16
Piping Requirements & Diagrams.....	17
General Notes & Disclaimers on Piping.....	17
Typical Piping Diagrams:	17
Pipe Insulation & Jacketing.....	28
HEAT2O CORE Control Scheme.....	28
HEAT2O CONNECT (SKID) and KIT Offering and Control Scheme	29
HEAT2O CONNECT (SKID) Offering.....	29
HEAT2O KIT Offering.	29
HEAT2O CONNECT (SKID) and KIT Control Scheme.....	30
Water Piping Freeze Protection Concerns and Recommendations.....	31
Outdoor Mounting and Cold Climate Installation Requirements.	33
Water Quality Considerations.....	35
Max Piping Distances and Elevation Difference Considerations.....	38
Max Piping Distance (QAHV to HX).....	39
Storage Tank Max Pressure.....	39

QAHV Max Allowable Static Pressure 39

SWEP HX Max Allowable Static Pressure.....39

Elevation Differences QAHV Below HX/Skid.....39

Elevation Differences QAHV Above HX/Skid 40

Elevation Differences QAHV & HX/Skid Above Tanks.....41

Typical High Rise Layout with >10 Floors Served.....41

High Temperature Ambient Conditions.....42

INTRODUCTION:

This document is a general application guide for the QAHV CO₂ HOT WATER HEAT PUMP. This document is to serve as a supplement to the technical data already contained within the Mitsubishi Electric CITY MULTI® engineering manuals, submittal sheets, and other service, operation and installation manuals.

This document will cover the product introduction and general application of the following products:

HEAT2O QAHV: QAHV-N136T/YAU-HPB

Please Note: This document covers the 2025 upgraded 3 their offering of QAHV including a SKID offering and revised controls, which differs from the previous Version #1 offering introduced in limited markets.

WHAT IS QAHV?

QAHV is an air to hot water heat pump unit that uses CO₂ as refrigerant and can provide hot water up to 176°F on the primary side, and over 150F water on secondary potable side (after separation HX), even at outdoor temperatures of -13°F, depending on application.

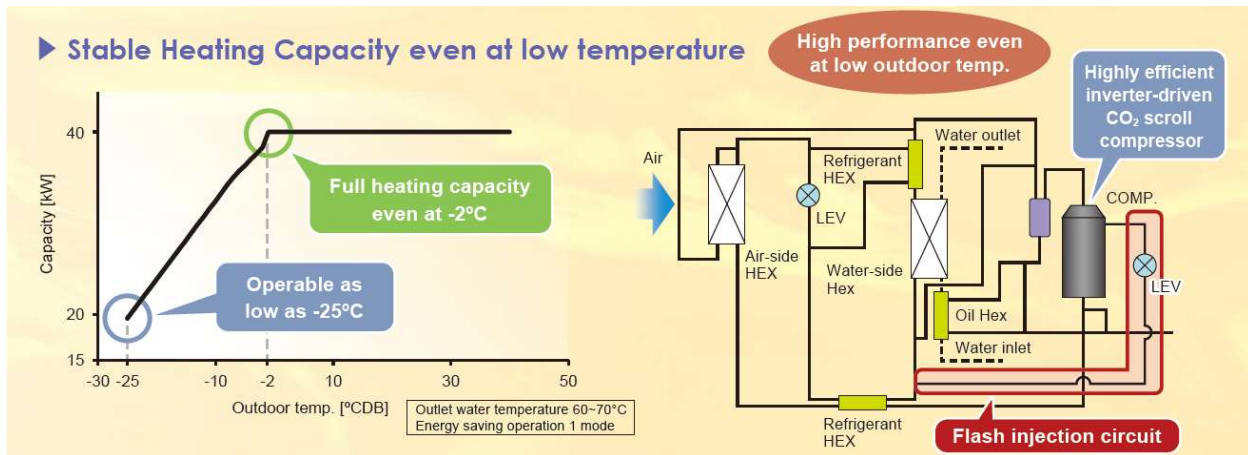
- Utilizes Natural refrigerant (CO₂)
- High efficiency (Achieved COP 3.88 *)
- Supplies High Temp Primary Hot water (up to 176°F)
- Operable at low outdoor temp (-13°F)
- Maintains 100% heating capacity to 36°F
- BMS connectivity
- 2 Operational Modes (Max and Energy Save)

Note: Unit must be used with separation HX.



QAHV is a dedicated inverter driven air source heat pump system that may be employed as a sole source heat pump water heater or in conjunction with other supplemental hot water heaters.

The QAHV also utilizes flash injection technology on CO₂ compressor to allow for higher sustained compressor speed at lower ambient conditions to maintain higher output capacity under low ambient conditions.

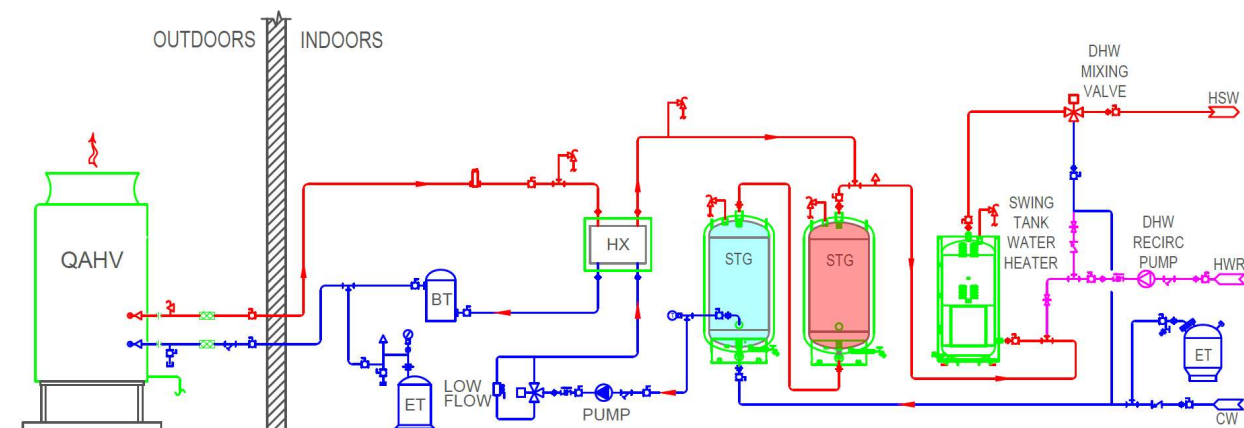


GENERAL SYSTEM APPLICATION & RATING DATA

General Application Considerations / Target Applications

QAHV is intended for high delta T application hot water needs, and specifically for end user potable hot water needs in facilities. This is inherently contrary to traditional heating hot water applications where lower delta T is common. The inherent efficiency of the QAHV is impacted by entering water temperature and thus potable water heating applications are ideal to achieve higher COP's. COP is maximized as the unit can be subject to colder storage tank temperatures by drawing from the bottom of primary domestic hot water storage tanks.

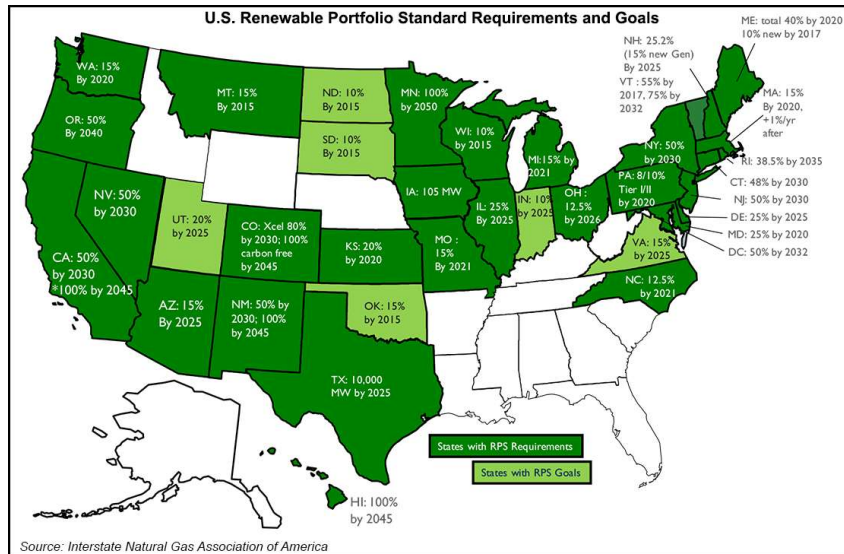
A typical general schematic utilizing the QAHV in a domestic hot water system is illustrated in below image. Note the required series tank arrangement to maintain low water temperatures to the QAHV unit to maximize efficiency.



Market Drivers – Carbon Reduction, Electrification, and Global Warming Reduction

Many states have begun to push towards electrification with increased renewables, smart grid technology and a shift away from coal fired generation in pursuit of renewable technology blended with cleaner peaking plant strategies. In this effort the goal to shift fossil fuel away from end user and implement heat

pump technology, for not only building heating needs, but also domestic water needs will become increasingly important.



Studies have identified building heating and domestic hot water needs as the largest remaining target items in buildings in the shift towards electrification – below from CBECS.

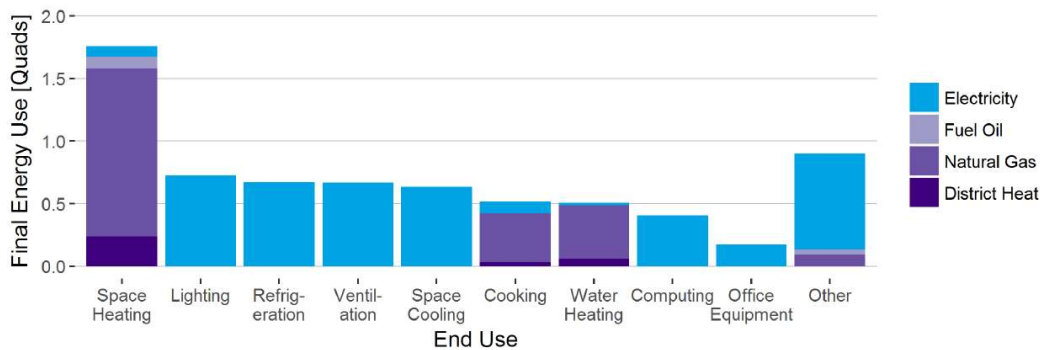


Figure 19. Final energy use in commercial buildings by end use and fuel type: 2012 CBECS

In the commercial buildings sector, a similar heavy reliance on natural gas and fuel oil is seen for space heating, water heating, and cooking (Figure 19). Replacement of these fossil fuel uses represents a significant potential for electrification in the residential and commercial buildings sector, particularly in the space and water heating end uses. Accordingly, this analysis focuses on

Also, since CO₂ is used as the refrigerant in the QAHV, this offers significantly lower global warming potential than other conventional refrigerants as well as zero ozone depleting potential. This is more suited to contributing to green initiatives and programs including but not limited to LEED enhanced refrigerant management.

System Operating Temperatures, Rating Charts, and Flow Rate Ranges

The QAHV capacity and efficiency will vary with ambient temperature, ambient humidity, outlet water temperature, and inlet water temperature. The published data books will provide detailed rating charts to determine net output capacity and resulting efficiency under varying conditions. The Selection Software should always be utilized in any design to determine final output capabilities at the project specific design conditions.

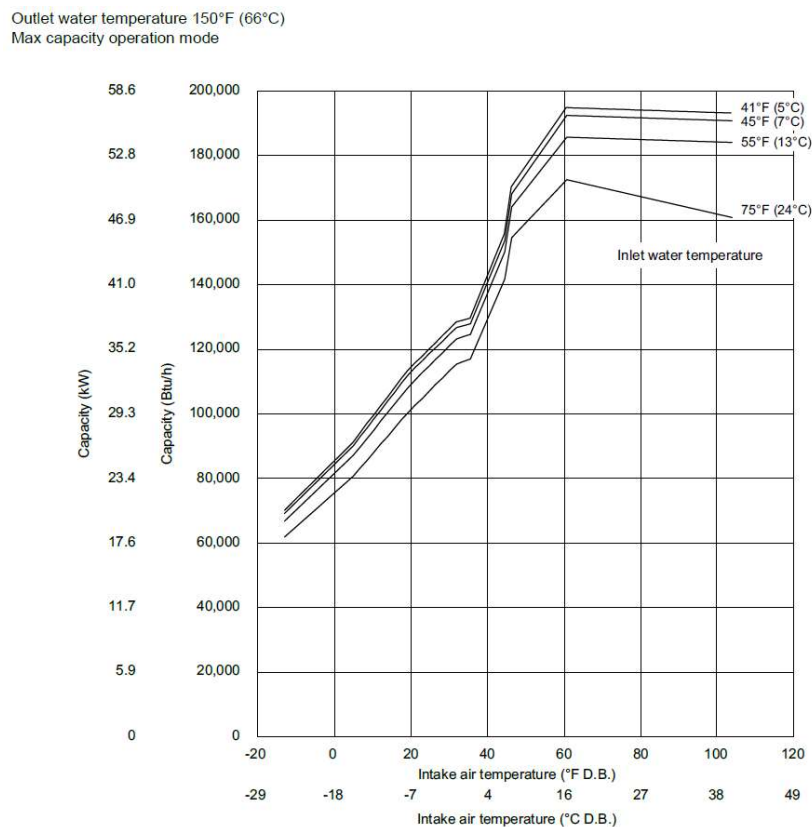
The QAHV will be capable of operating in different modes for peak capacity outputs settings in exchange for operating efficiency.

The two modes offered are:

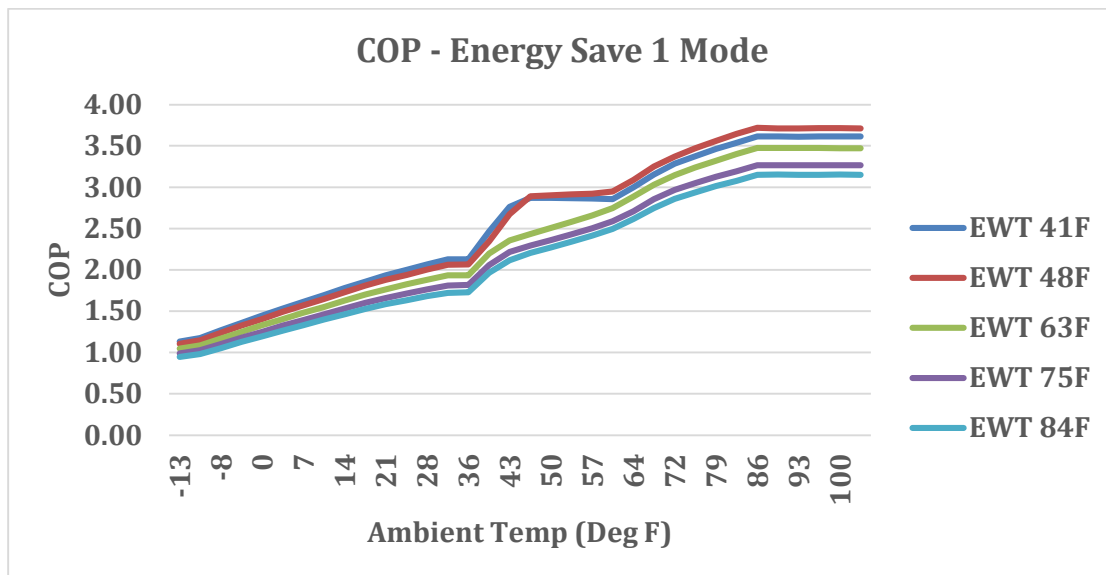
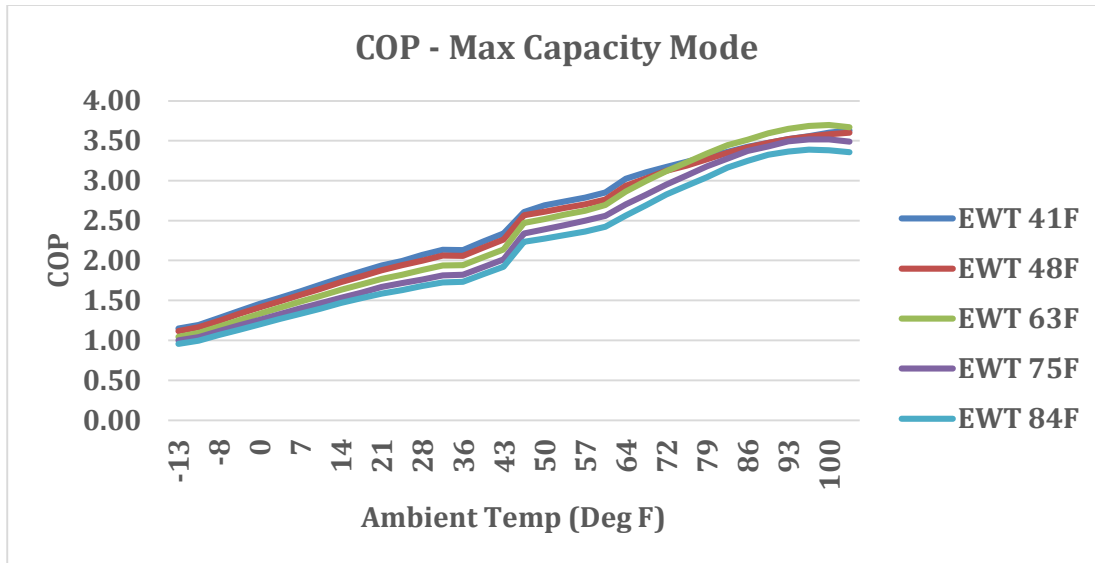
- Maximum Capacity Operation (<58KW on UL Model)
- Energy Save Mode 1 Operation (40 KW)

Data Book charts should be consulted for capacity output corrections for ambient, inlet water, outlet water, and defrost for each of the modes listed above. The selection software will also provide these corrections based on design conditions.

An example of a typical Data Book Chart showing capacity and power correction (Maximum Capacity Mode) is illustrated below with outlet water of 66C/150F.



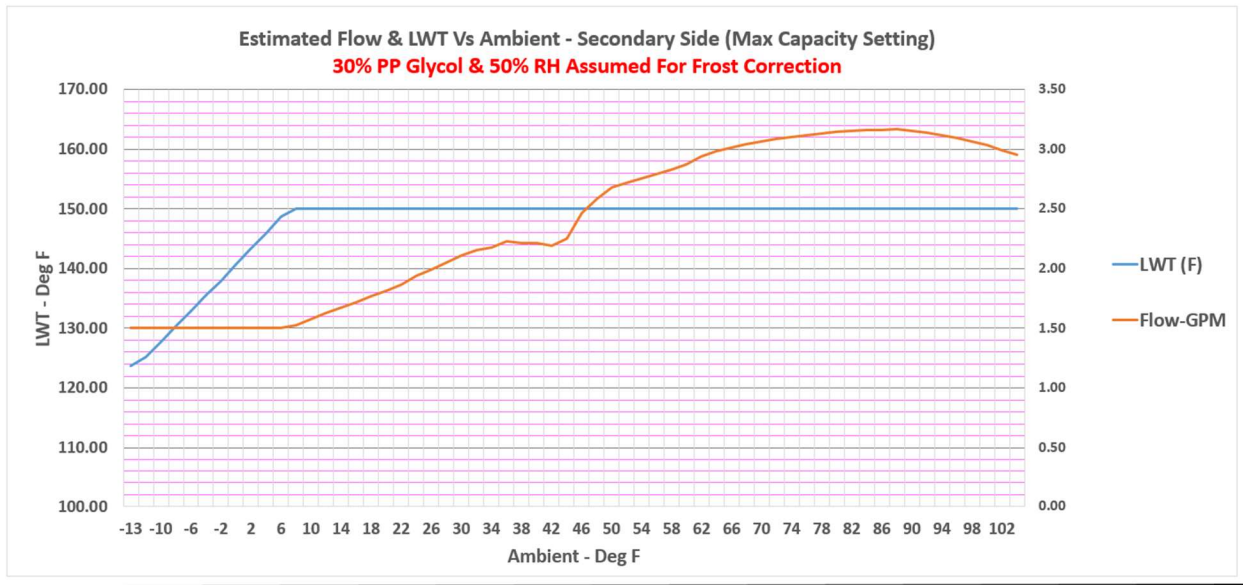
Some examples of typical efficiency values based on Data Book published correction factor charts for each of the modes is illustrated below. Please note that other corrections for defrost must be applied additionally and can be found in published Data Books.



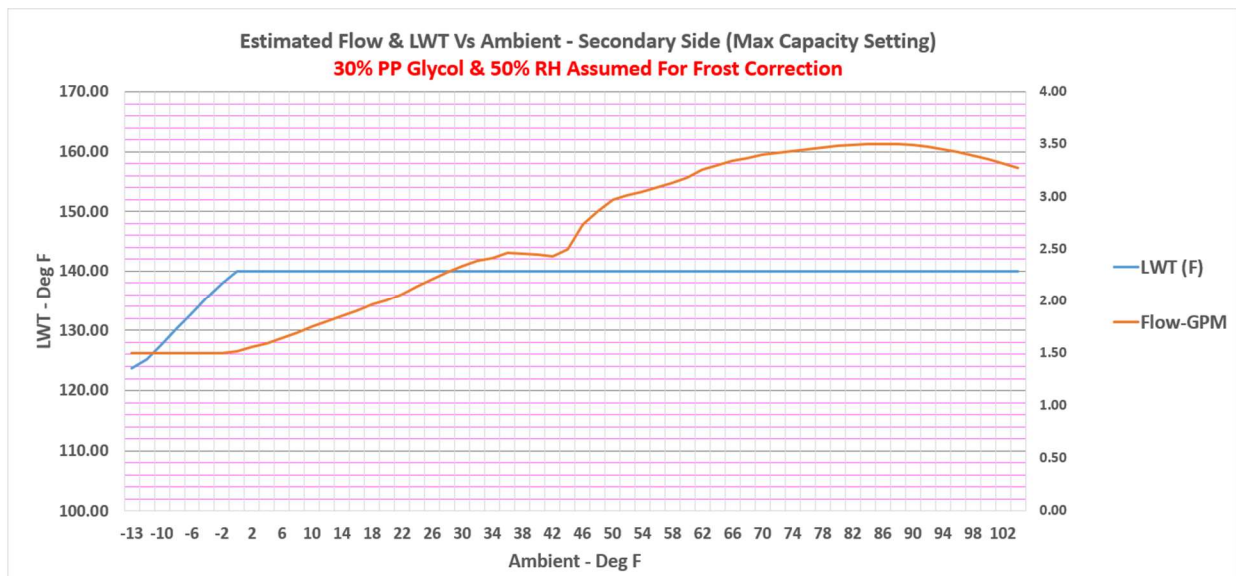
Flow rate range for the QAHV is in the 0.8 to 8 gpm range. It is important to have adequate flow modulation capability, especially during colder ambient periods where QAHV is de-rated. If flow rate cannot be modulated down to around 1.0 gpm minimum discharge water temperature may drop on the QAHV at colder ambient conditions. **The below chart illustrates this for a case where flow rate turndown is limited to only 1.5 gpm for 150F and 140F target supply temperature to the storage tanks from the separation HX on potable side.**

With HEAT20 CONNECT(SKID) & KIT offering (discussed later), enhanced pump controls with a 3-way tow position valve and low flow balance are present to achieve high flow turndown, which is important for cold climate applications. This will be illustrated in the sample piping diagrams later in this application guide.

Turndown Flow (gpm)	1.5
Secondary Temp Required (F)	150 Max of 160F
QAHV Inlet Water Temp (F)	66
EWT (Secondary), (F)	47 With Double Wall HX Approach



Turndown Flow (gpm)	1.5
Secondary Temp Required (F)	140 Max of 160F
QAHV Inlet Water Temp (F)	66
EWT (Secondary), (F)	47 With Double Wall HX Approach



APPLICATION DETAILS & DESIGN CONSIDERATIONS

Primary Heat Exchanger Loop & QAHV Direct Potable Water Connection Concerns

The QAHV primary heat exchanger (HX) is comprised of a unique spiral wound HX where refrigerant pipe tubing is wrapped around a twisted water pipe in the HX design. This offers a double containment benefit while maintaining efficient heat transfer; however, due to scale and corrosion concerns with open potable water in such small tubing, a separation HX and sealed loop should be used in lieu of connecting potable water directly to unit. The unit is equipped with an integral pump intended to deliver heated water through a closed loop with a primary separation HX. This HX will be available as a pre-configured field installed device or as part of a skid solution.

High Energy Saving Gas Cooler - Patented Technology

Unique to Mitsubishi Electric, QAHV utilises a twisted and spiral gas cooler. Using twisted pipes as water pipes and running the refrigerant pipes along their grooves helps to increase the heat-conductive area; allowing for better heat transfer and an impressive COP of 3.88*. The continuous spiral groove design accelerates the turbulence effect of water and helps to reduce pressure loss within the heat exchanger, enhancing efficiency. Equipped with the latest inverter scroll compressor, QAHV offers unparalleled efficiency when compared to fixed speed systems.



Twisted water pipe with the refrigerant pipe spiralled around it



Primary Loop Hot Water to Potable Water HX includes capability to handle the 2 operational modes of QAHV described above:

With HEAT20 CONNECT(SKID), KIT & CORE offering this heat exchanger will be double wall construction and suitable for use with glycol on primary side for added freeze protection of closed primary loop.



Primary Separation Loop Expansion Tank Considerations & Buffer Volume.

Since the primary side of the QAHV is a closed system between QAHV and primary separation heat exchanger, water volume expansion must be considered and provided via an expansion tank to maintain integrity of the loop and operate within pressure limits of system and requirements by code.

Typically, pre charged bladder style tanks would be used in closed system and expansion of system fluid would be governed by below formulation (Formula 1, below). Please note that the $3\alpha\Delta t$ term in numerator of formula is for piping expansion allowance for net piping thermal expansion and resulting pipe volume increase; however, this is seldom used and for conservatism can be omitted.

Low temperature should be selected near low limit winter city water feed temperatures or freeze protection cycle minimum temperature of QAHV of around 40F. High temperature should be selected at maximum primary supply temperature; 180F recommended for conservatism.

If initial system fill temperature varies significantly (higher) from low temperature freeze protection temperature, then pre charge pressure of tank may need to be adjusted to a slightly higher pressure during initial fill which can be obtained by examining ratio of volume change of system water between fill temp and low limit temp.

Expansion tanks should always be installed near suction side of system indoors and static column fill will need to be considered for P1 to ensure the highest piping location has >5 psig under system idle conditions to promote air purge. Generally, separation HX should be located close to the expansion tank indoors to minimize this difference in static column head between HX and expansion tank.

The heat exchanger incorporates an upgraded double wall vented construction; thus, concerns of primary pressure vs city water pressure in leakage event are no longer an issue, as was the case with prior version #1 QAHV single wall construction on the separation HX.

For expansion tank sizing. Elevation differential between the QAHV and the separation HX and those effects on fill pressure at the expansion tank location should be considered. Also, the dynamic pressure differential between the relief valve and the expansion tank connection when the primary pump is operating should be considered as there will be pressure drop between the relief valve connection point

and the expansion tank connection point when system is in operation (see piping diagrams section of application note).

$$V_T = V_S * \frac{\left[\left(\frac{v_2}{v_1}\right) - 1\right] - 3\alpha\Delta t}{1 - (P_1/P_2)}$$

(Formula 1 - Bladder Style Tank Sizing Formulation)

Variable	Description (units)
V_T	expansion tank volume (gal)
V_S	system volume (gal)
v_1	specific volume at lower temperature $\left(\frac{ft^3}{lb}\right)$
v_2	specific volume at higher temperature $\left(\frac{ft^3}{lb}\right)$
α	linear coefficient of thermal expansion $\left(\frac{in}{in\ ^\circ F}\right)$
Δt	higher temperature – lower temperature ($^\circ F$)
P_1	pressure at lower temperature (psia)
P_2	pressure at higher temperature (psia)

The primary loop also requires a minimum water volume capacitance to reduce short cycling issues. The factory requires a minimum of 10.7 gallons of water volume. **With the SKID (HEAT20 CONNECT) a 10-gallon ASME buffer tank will be provided.**

Storage Tank & Swing Tank Considerations

The QAHV is intended to work in conjunction with a primary storage volume to fulfill the domestic hot water needs. For most applications, to achieve cost effective solutions, the QAHV will be utilized in a thermal storage load leveling strategy where storage volume is larger (often times two times traditional systems) to cover peak load demands. The QAHV will then operate the majority of occupied hours or longer (typically available 16hrs per day) to recovery draw from the primary tank with the highest delta T possible to maintain efficiency.

Typical storage temperatures are recommended in the 140-160F range, depending on climate and de-rates, in order to maintain sanitary storage conditions to protect against Legionella. Downstream electronic mixing valves are required to produce delivery temperature to building fixtures. Downstream mixing valves and building hot water recirculation pumps would be by others / field supply and are outside the scope of this document.

Please note: This product may assist in maintaining water quality when properly installed and maintained. However, risk of Legionella cannot be entirely eliminated by any single device or method. Owners and operators are responsible for adhering to all prevailing health and safety regulations, and for implementing comprehensive Legionella prevention and water management protocols as required by law and/or as recommended under national or regional guidance, such as ASHARE Guideline 12.

For low load periods where recovery is complete, a swing tank with heater should be used to cover piping distribution heat losses in the hot water recirculation system. Since the QAHV is better suited for high

delta T operation and efficiency is maximized for high delta T operation, the swing tank with heater for idle conditions offers better control of maintenance loads, reserving the QAHV for draw down events and main tank recovery. The design engineer of record must evaluate piping system distribution losses to determine swing tank heater requirements.

Storage tank pressure is typically limited to 125psig. The tank accessory options offered (covered in next section) are rated for this as well. To be conservative 100 psig max working design pressure should be considered for tank install location and number of floors served in relative position to any booster pump systems if present in building design.

Tank Options Available & Minimum Storage

The QAHV product will be available with several storage Tank accessory options to build and scale the system desired. Storage volume requirements exceeding the largest tank available can be combined in series – see piping diagrams section for examples.

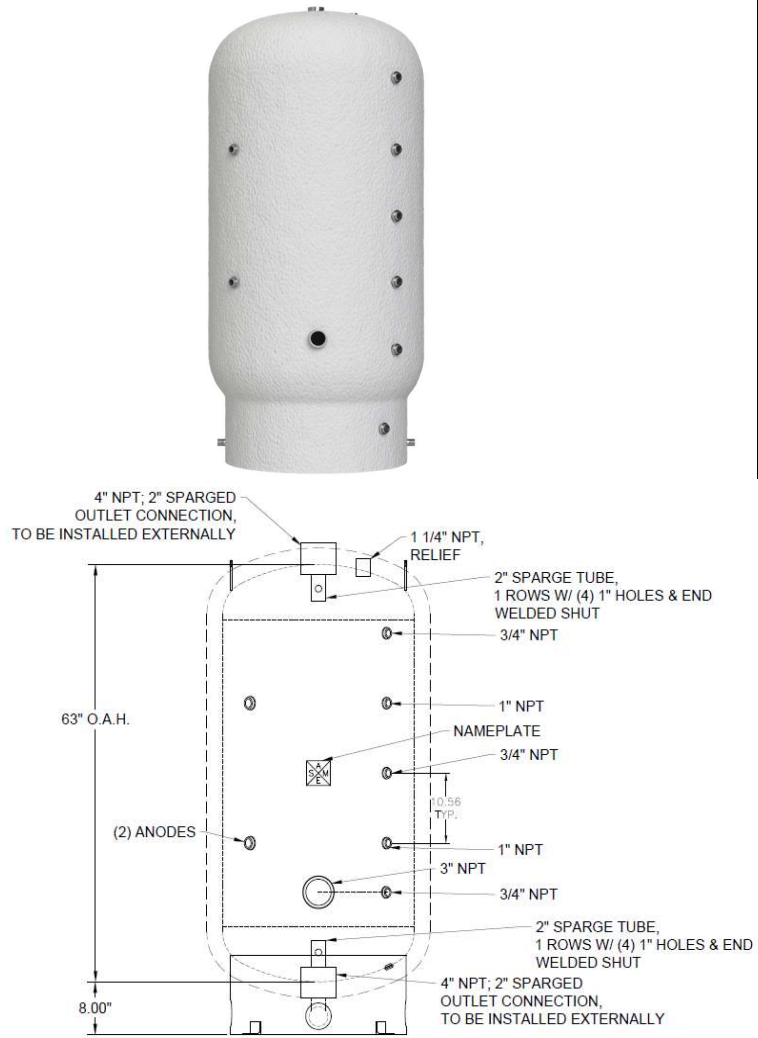
Swing tanks must be procured by others and are not provided by Mitsubishi Electric Trane HVAC US LLC (METUS).

Each QAHV system MUST have sufficient storage water volume:

- Minimum 285 gallons for single QAHV.
- Minimum 500 gallons per Qty2 QAHV units.

Primary Storage Tanks Options Include:

- 175, 285, 500.
- Tanks include sparge tube to reduce turbulence, increase efficiency, and maintain improved stratification for successful draw down event.
- 125psig rated (design for 100psig max recommended).
- **Example image and dimensions of 175 gallon tank shown to right:**
- ***Note – the 175 gallon tank is only tank option that will fit through a standard 3ft wide door.***
- Tanks are offered in glass lined and Duplex Stainless.



2025 New 3 Tier Offering

HEAT20 CORE

This is an upgrade to the Version#1 control scheme. This still relies on a DC pump with integral temperature controls but removes the factory thermal on/off staging directly by QAHV and controls thermal on/off and tank temperature sensing through a supervisory panel. This changes the configuration of QAHV systems as they now operate independently, even when part of larger plant which allows for staging control of each QAHV/HX/Pump pair as part of larger plant.

HEAT20 KIT

This is an upgraded control scheme that removes temperature control from the HX DC pump and incorporates flow tracking and monitoring on both primary side (QAHV side) and secondary side (potable side) for increased efficiency, COP monitoring, and ultra-low flow turndown in colder climates. This also removes the factory standard thermal on/off controls and incorporates a dedicated tank temperature monitoring panel for controlling individual staging. This solution is still completely a field-installed configuration in terms of piping and wiring for the HX/Pump/Tank sensing indoors. **Please note the KIT does NOT contain the buffer tank and expansion tank – those are still field provided.**

HEAT20 CONNECT (SKID)

This is an upgraded control scheme that removes temperature control from the integral HX DC pump and incorporates flow tracking and monitoring on both primary side (QAHV side) and secondary side (potable side) for increased efficiency, COP monitoring, and ultra-low flow turndown in colder climates. This also removes the factory standard thermal on/off controls and incorporates a dedicated tank temperature monitoring panel for controlling individual staging. **This solution provides all the components for HX/Pump (with buffer tank and expansion tank), including control in a single skid package.**

New 3 Tier Summary Comparison:

	HEAT ₂ 0 CONNECT (SKID)	HEAT ₂ 0 KIT (NO SKID)	HEAT ₂ 0 Core
How It Ships	Pre Assembled SKID	Bundled Parts In Crate - Field Install	All Loose Parts - Field Install
Controls	Advanced/Flow Tracking	Advanced/Flow Tracking	Basic Controls
Equipment Cost	Highest	Higher	Lowest
Installation Time & Cost	Lowest	Highest	Moderate
New Double Wall HX (up to 30% PP Glyc)	YES	YES	YES
Ultra Low Flow Turndown	YES	YES	NO
Low ambient Maintained DWT - Note 1	-13 Deg F	-13 Deg F	0F
Flow Tracking For Optimal Efficiency	YES	YES	NO
Staging with lead/lag functions	YES	YES	YES
Individual Controllers Per HX/Pump	YES	YES	NO
Additional IO Controller Option	YES	YES	CUSTOM
Installer Wiring Expertise Level	MODERATE	ADVANCED	MODERATE/LOW
Control Panel Quantity (w/o Added IO)	1 Per QAHV + Sup	1 Per QAHV + Sup	1
Max Number Of QAHV Supported	16	16	16
Energy Calculation	YES	YES	CUSTOM
Onsight Programming Required	NO	NO	Minor - Pump

Note 1 - Ambient temperatures listed are general guidelines. Actual low ambient maintained leaving water temperature will depend on target LWT desired, ambient conditions, total derate with frost and glycol, and secondary pump balanced turndown. Consult with Mitsubishi representative for further guidance during design stage.

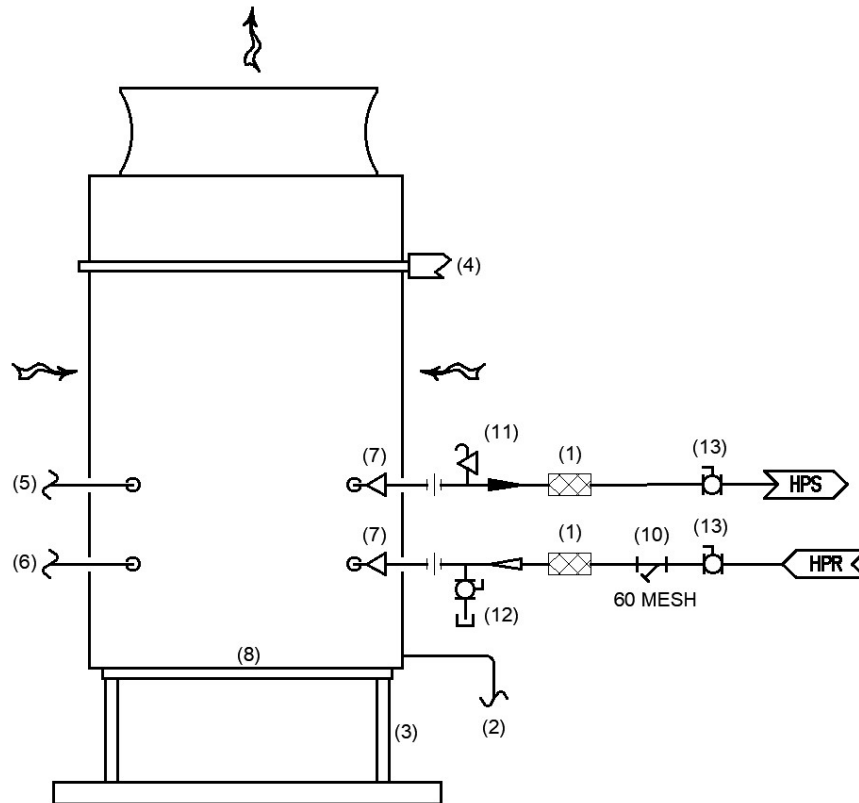
Piping Requirements & Diagrams

General Notes & Disclaimers on Piping

- Final piping and all final field specialties not furnished by manufacturer are the responsibility of design engineer of record. Drawings are not to be used solely in place of professional engineering services required, comply with all local and state specific codes.
- Final mounting requirements for equipment and piping anchorage may not be fully specified in these drawings and final considerations for wind/seismic must be made by engineer of record.
- No added warranty or guarantee, expressed or implied, is made by the representation in these drawings. These are intended as a working guide for professional engineer of record. Original equipment warranties remain subject to published warranty terms on public domain.
- Complete building domestic hot water design and distribution is outside the scope of these drawings including but not limited to, fixture demand, fixture selection, branch and main line sizing, sizing/determination of pressure zones and or pressure booster pumps, hot water mixing valve, etc.

Typical Piping Diagrams:

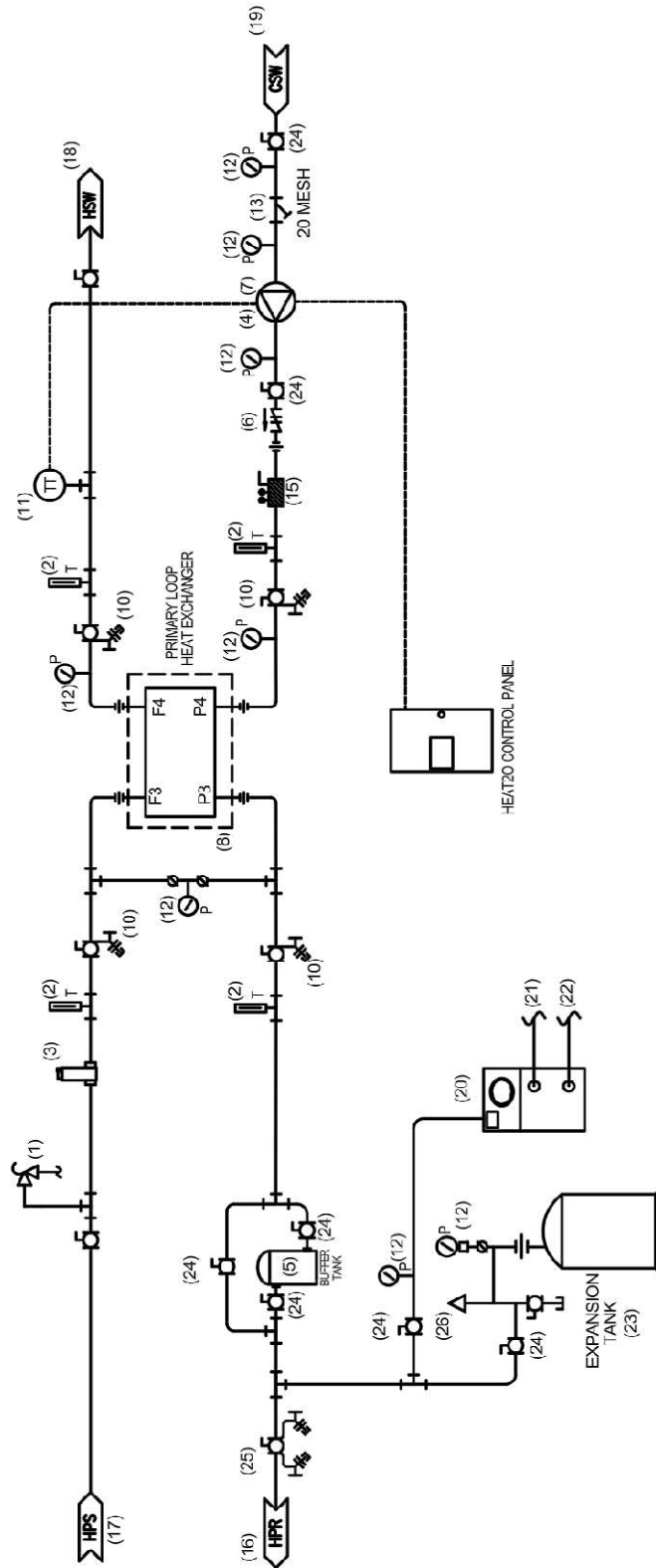
Below: QAHV Outdoor Installation Detail



NOTES:

1. FLEX CONNECTIONS (BY CONTRACTOR).
2. ROUTE UNIT CONDENSATE OUTLET TO NEAREST DRAIN - HEAT TRACE IN COLD CLIMATES (HEAT TRACE BY OTHERS).
3. IN COLD CLIMATES, INSTALL THE UNIT ON A MINIMUM 18-INCH HIGH RAISED OPEN BASE TO PREVENT DAMAGE FROM SNOW.
4. PROVIDE SEISMIC BRACING WHERE REQUIRED BY JURISDICTION (BY CONTRACTOR).
5. ELECTRICAL POWER CONNECTION (BY CONTRACTOR).
6. CONTROL WIRE CONNECTION (BY CONTRACTOR).
7. BSP TO NPT PIPE ADAPTER (BY MANUFACTURER, SHIPPED WITH UNIT).
8. IN COLD CLIMATES HEAT TRACE UNIT BASE PAN AND CONDENSATE COLLECTION PAN (BY CONTRACTOR).
9. IN COLD CLIMATES HEAT TRACE ALL WATER PIPING OUTDOORS (BY CONTRACTOR). ENSURE HEAT TRACE AND INSULATION COVERS ALL EXPOSED HYDRONIC ACCESSORIES.
10. PROVIDE STRAINER WITH 60 MESH MINIMUM (BY CONTRACTOR).
11. MANUAL AIR VENT (BY CONTRACTOR).
12. LOW POINT DRAIN (BY CONTRACTOR).
13. ISOLATION VALVE (BY CONTRACTOR).

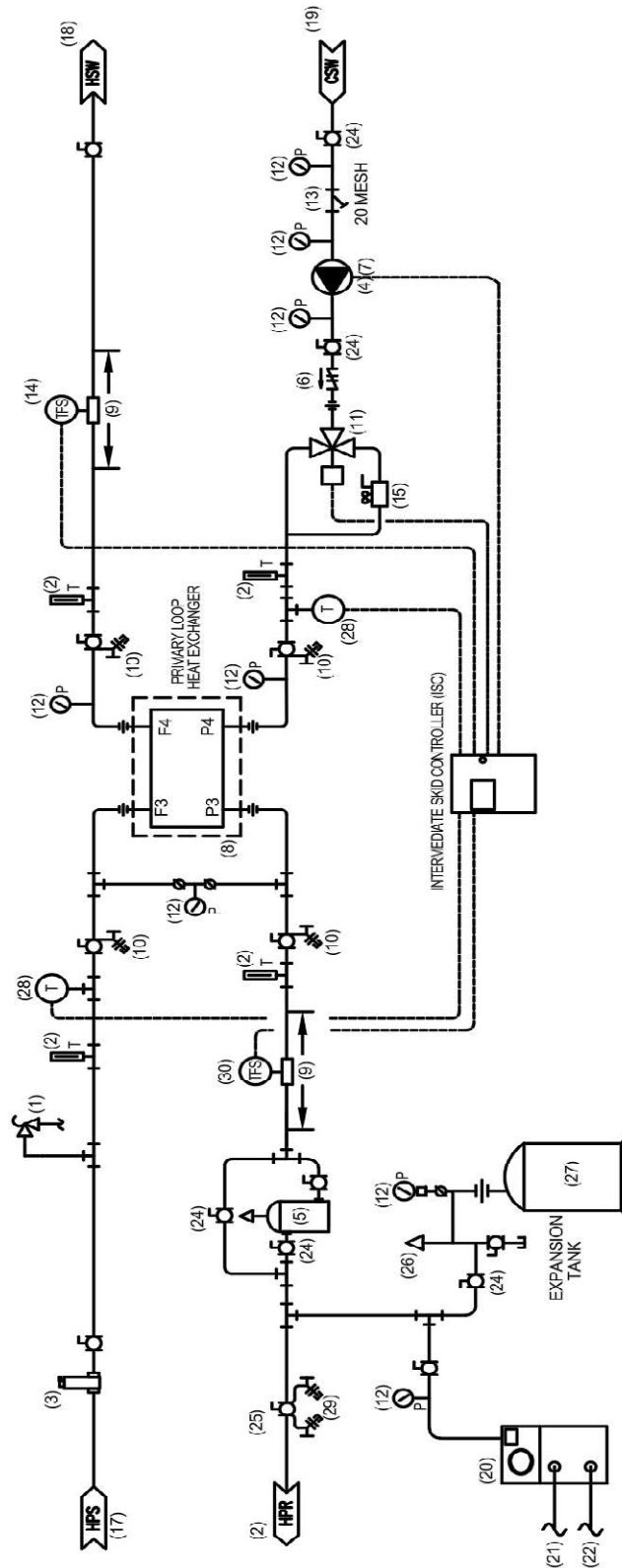
Below: QAHV Primary Separation Loop & Heat Exchanger (HEAT20 CORE)



NOTES:

1. PRESSURE/TEMPERATURE RELIEF VALVE (BY CONTRACTOR). ROUTE OUTLET TO NEAREST DRAIN.
2. 200°F IMMERSION TYPE THERMOMETER (BY CONTRACTOR).
3. MICROBUBBLE AIR AND DIRT SEPARATOR (BY CONTRACTOR).
4. PROVIDE CUSH-A-THERM SUPPORTS (OR SIMILAR) WITHIN 6" OF EITHER SIDE OF PUMP (BY CONTRACTOR).
5. 10-GALLON BUFFER TANK WITH TWO 1" CONNECTIONS AND BYPASS (BY CONTRACTOR).
6. INLINE SPRING CHECK VALVE (BY CONTRACTOR).
7. SECONDARY SIDE DC PUMP WITH REMOTE DISCHARGE TEMP SENSOR, INTEGRAL TEMP CONTROLLER AND INTEGRAL FLOW METERING. PUMP SHALL BE GRUNDFOS MAGNA 3 AND PROVIDED AS PACKAGE WITH QAHV BY MANUFACTURER. TEMP SET POINT RANGE UP TO 170F, FLOW RANGE LIMIT ADJUSTABLE FROM 0.8 GPM TO 8 GPM. AUX INPUT FOR ANTI-FREEZE MODE SIGNAL CONTACT CLOSURE FROM QHAV FOR 17 L/MIN (4.5 GPM) FIXED FLOW.
8. PROVIDE INSULATION BLANKET (BY CONTRACTOR).
9. ENSURE FLOW SWITCH MANUFACTURER REQUIRED UPSTREAM AND DOWNSTREAM STRAIGHT PIPE LENGTHS ARE MET TO ENSURE ACCURACY OF FLOW SWITCH FUNCTION.
10. ISOLATION/FLUSHING VALVES USED FOR ISOLATING, DRAINING AND CLEANING (BY CONTRACTOR).
11. REMOTE TEMPERATURE SENSOR ON LEAVING POTABLE SIDE OF SEPARATION HX (BY MANUFACTURER). LOCATE SENSOR CLOSE TO STORAGE TANKS - CONSULT REPRESENTATIVE FOR GUIDANCE.
12. PROVIDE A PRESSURE GAUGE WITH NORMALLY CLOSED SHUT-OFF GAUGE VALVE/S (BY CONTRACTOR).
13. PROVIDE STRAINER WITH 20 MESH MINIMUM WITH CAPABILITY TO ACCEPT ACCESSORY STRAINER ELEMENTS UP TO 60 MESH DEPENDING ON POTABLE WATER QUALITY (BY CONTRACTOR). SIZE PUMP FOR WORST CASE INSTALLED PRESSURE DROP.
14. NOT USED.
15. PROVIDE POTABLE RATED CALIBRATED ADJUSTABLE BALANCE DEVICE WITH 0.8 GPM MINIMUM FLOW SETTING AND 8 GPM MAXIMUM FLOW SETTING (BY CONTRACTOR).
16. PRIMARY HOT WATER RETURN RETURN TO HEAT PUMP.
17. PRIMARY HOT WATER SUPPLY FROM HEAT PUMP.
18. SECONDARY HOT WATER SUPPLY TO STORAGE TANKS.
19. SECONDARY COLD WATER RETURN FROM STORAGE TANKS.
20. PROVIDE GLYCOL SYSTEM FEEDER SIZED FOR 10% OF PRIMARY LOOP VOLUME. EXPANSION TANK AIR PRESSURE TO BE ADJUSTED TO THE COLD FILL / SYSTEM FEEDER SET POINT PRIOR TO FILLING SYSTEM (BY CONTRACTOR).
21. CONTROL WIRE CONNECTION FOR MONITORING (BY CONTRACTOR).
22. ELECTRICAL POWER CONNECTION (BY CONTRACTOR).
23. PRIMARY LOOP EXPANSION TANK (BY CONTRACTOR).
24. ISOLATION VALVE (BY CONTRACTOR).
25. PURGE AND FILL VALVE OR VALVE ASSEMBLY WITH THREADED HOSE DRAIN CONNECTIONS (BY CONTRACTOR).
26. AUTOMATIC AIR VENT (BY CONTRACTOR).

Below: QAHV Primary Separation Loop & Heat Exchanger (HEAT20 KIT)



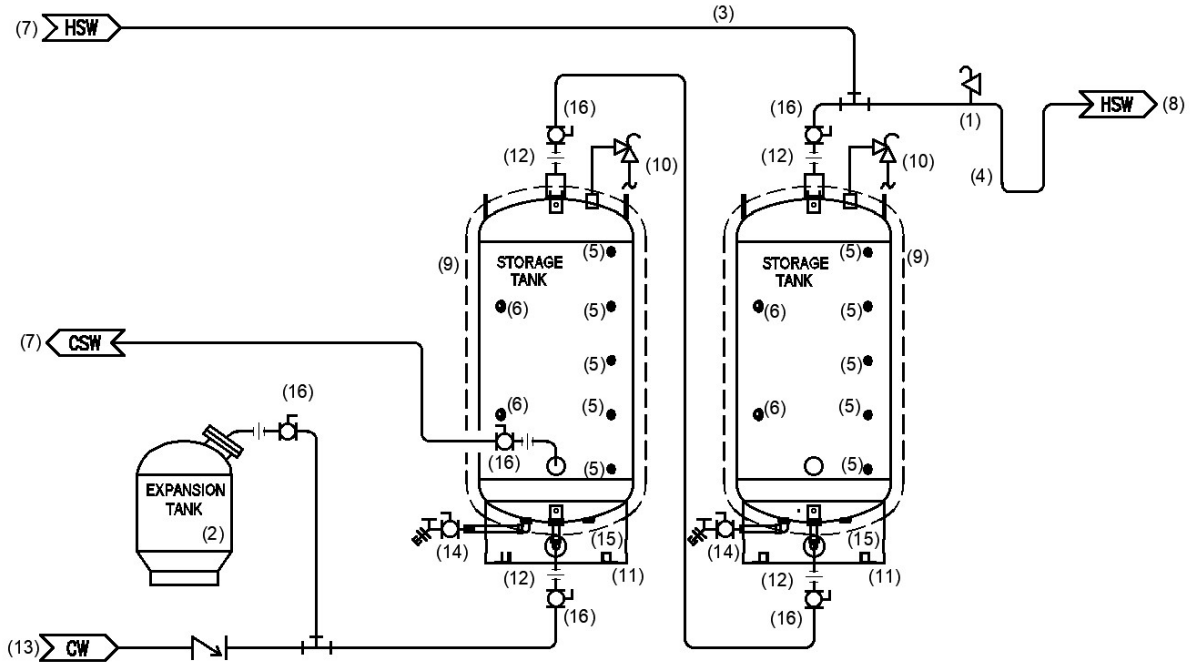
NOTES:

1. PRESSURE/TEMPERATURE RELIEF VALVE (BY CONTRACTOR). ROUTE OUTLET TO NEAREST DRAIN.
2. 200°F IMMERSION TYPE THERMOMETER (BY CONTRACTOR).
3. MICROBUBBLE AIR AND DIRT SEPARATOR (BY CONTRACTOR), LOCATE AT HIGHEST ELEVATION IN PIPING RUN INDOORS.
4. PROVIDE CUSH-A-THERM SUPPORTS (OR SIMILAR) WITHIN 6" OF EITHER SIDE OF PUMP (BY CONTRACTOR).
5. 10-GALLON BUFFER TANK WITH TWO 1" CONNECTIONS AND BYPASS (BY CONTRACTOR).
6. INLINE SPRING CHECK VALVE (BY CONTRACTOR).
7. INSTALL SECONDARY MODULATED GRUNDFOSS PUMP, WIRED TO AND CONTROLLED BY INTERMEDIATE CONTROLLER (ISC) - FURNISHED BY MANUFACTURER.
8. INSTALL DOUBLE WALL HEAT EXCHANGER, FURNISHED BY MANUFACTURER. FIELD PROVIDE INSULATION BLANKET (BY CONTRACTOR).
9. ENSURE FLOW SWITCH MANUFACTURER REQUIRED UPSTREAM AND DOWNSTREAM STRAIGHT PIPE LENGTHS ARE MET TO ENSURE ACCURACY OF FLOW SWITCH FUNCTION.
10. ISOLATION/FLUSHING VALVES USED FOR ISOLATING, DRAINING AND CLEANING (BY CONTRACTOR).
11. INSTALL LEAD FREE 3 WAY DIVERTING VALVE FOR LOW FLOW BALANCE POSITION - WIRED TO AND CONTROLLED BY INTERMEDIATE CONTROLLER (ISC), FURNISHED BY MANUFACTURER.
12. PROVIDE A SINGLE PRESSURE GAUGE WITH NORMALLY CLOSED SHUT-OFF GAUGE VALVE/S BY CONTRACTOR).
13. PROVIDE STRAINER WITH 20 MESH MINIMUM WITH CAPABILITY TO ACCEPT ACCESSORY STRAINER ELEMENTS UP TO 60 MESH DEPENDING ON POTABLE WATER QUALITY (BY CONTRACTOR). SIZE PUMP FOR WORST CASE INSTALLED PRESSURE DROP.
14. INSTALL COMBINATION FLOW AND TEMPERATURE SENSOR (IFM MODEL SU8621, NSF RATED, POTABLE SIDE ONLY) FOR PROOF OF FLOW, TEMPERATURE CONTROL AND PRIMARY/SECONDARY FLOW TRACKING (MANAGED BY INTERMEDIATE SKID CONTROLLER (ISC)) - ADJUSTABLE WITH MINIMUM FLOW ON SETTING CAPABILITY, FURNISHED BY MANUFACTURER, WIRED TO INTERMEDIATE SKID CONTROLLER (ISC).
15. INSTALL LEAD FREE POTABLE RATED CALIBRATED ADJUSTABLE BALANCE DEVICE FOR 0.8 GPM BALANCED AT MIN PUMP SPEED (FURNISHED BY MANUFACTURER)
16. PRIMARY HOT WATER RETURN RETURN TO HEAT PUMP.
17. PRIMARY HOT WATER SUPPLY FROM HEAT PUMP.
18. SECONDARY HOT WATER SUPPLY TO STORAGE TANKS.
19. SECONDARY COLD WATER RETURN FROM STORAGE TANKS.
20. PROVIDE GLYCOL SYSTEM FEEDER SIZED FOR 10% OF PRIMARY LOOP VOLUME.
21. CONTROL WIRE CONNECTION FOR MONITORING (BY CONTRACTOR).
22. ELECTRICAL POWER CONNECTION (BY CONTRACTOR).
23. PRIMARY LOOP EXPANSION TANK (BY CONTRACTOR).
24. ISOLATION VALVE (BY CONTRACTOR).
25. PURGE AND FILL VALVE OR VALVE ASSEMBLY WITH THREADED HOSE DRAIN CONNECTIONS (BY CONTRACTOR). USE FILL CART FOR INITIAL FLUSH/FILL.
26. AUTOMATIC AIR VENT (BY CONTRACTOR).
27. EXPANSION TANK AIR PRESSURE TO BE ADJUSTED TO THE COLD FILL / SYSTEM FEEDER SET POINT PRIOR TO FILLING SYSTEM (BY CONTRACTOR).
28. INSTALL TEMPERATURE SENSOR, FURNISHED BY MANUFACTURER, WIRED TO INTERMEDIATE SKID CONTROLLER (ISC).
29. USE FLUSH CART FOR INITIAL FILL. IF PRE-MIX IS NOT PROCURED, MIX AS REQUIRED USING DEMINERALIZED WATER AND GLYCOL FOR INITIAL FILL.
30. INSTALL FLOW SENSOR (IFM MODEL SU8631, GLYCOL RATED - NOT FOR POTABLE SIDE) FOR PROOF OF FLOW AND PRIMARY/SECONDARY FLOW TRACKING (MANAGED BY INTERMEDIATE SKID CONTROLLER (ISC)) - ADJUSTABLE WITH MINIMUM FLOW ON SETTING CAPABILITY, FURNISHED BY MANUFACTURER, WIRED TO INTERMEDIATE SKID CONTROLLER (ISC).

NOTES:

1. ADJUSTABLE PRESSURE RELIEF VALVE ON SKID - SET PRV IN FIELD
2. PRIMARY HOT WATER RETURN RETURN TO HEAT PUMP.
3. PRIMARY HOT WATER SUPPLY FROM HEAT PUMP.
4. MICROBUBBLE AIR AND DIRT SEPARATOR (BY CONTRACTOR), LOCATE AT HIGHEST ELEVATION IN PIPING RUN INDOORS.
5. SKID BOUNDARY - SEE FULL SKID SUBMITTAL PACKET FOR ALL INTERNAL DETAILS
6. CALIBRATED ADJUSTABLE BALANCE DEVICE (INTEGRAL TO SKID) - SET FOR 0.8 GPM BALANCED AT MIN PUMP SPEED - SEE SKID STARTUP INSTRUCTIONS.
7. SECONDARY HOT WATER SUPPLY TO STORAGE TANKS.
8. SECONDARY COLD WATER RETURN FROM STORAGE TANKS.
9. PROVIDE A PRESSURE GAUGE MEASURE PRESSURE (BY CONTRACTOR).
10. EXPANSION TANK AIR PRESSURE TO BE ADJUSTED TO THE COLD FILL / SYSTEM FEEDER SET POINT PRIOR TO FILLING SYSTEM (BY CONTRACTOR).
11. PROVIDE GLYCOL SYSTEM FEEDER SIZED FOR 10% OF PRIMARY LOOP VOLUME
12. CONTROL WIRE CONNECTION FOR MONITORING (BY CONTRACTOR).
13. ELECTRICAL POWER CONNECTION (BY CONTRACTOR).
14. USE FLUSH CART FOR INITIAL FILL. IF PRE-MIX IS NOT PROCURED, MIX AS REQUIRED USING DEMINERALIZED WATER AND GLYCOL FOR INITIAL FILL.

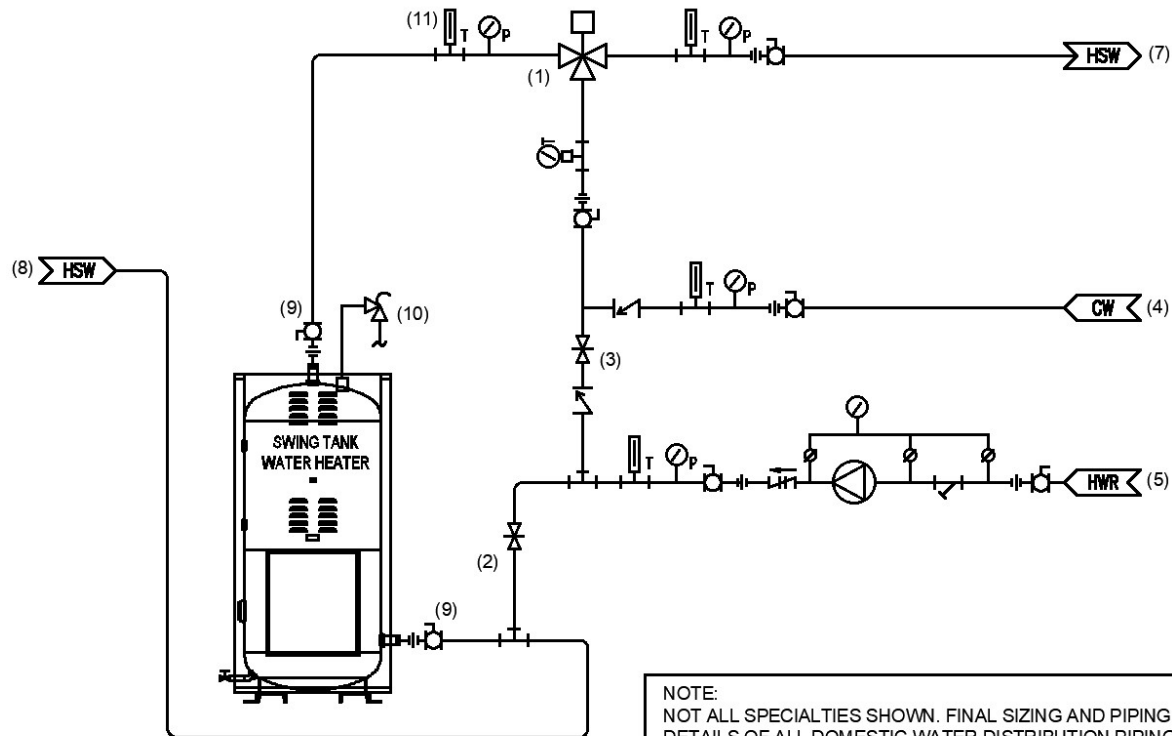
Below: Storage Tank Detail - Two Tank Storage
(Similar For Additional Series Tanks)



NOTES:

1. PROVIDE AUTOMATIC AIR VENT WITH SERVICING CHECK VALVE AT HIGH POINT (BY CONTRACTOR).
2. EXPANSION TANK (BY CONTRACTOR).
3. PROVIDE HOT WATER MANIFOLD WITH MINIMUM 1.5 INCHES OF 0.25 U-VALUE INSULATION (BY CONTRACTOR). PIPE DIMENSIONS SHALL MATCH TANK CONNECTION SIZE.
4. PROVIDE HEAT TRAP PIPING (BY CONTRACTOR). DROP PIPE MINIMUM OF 12" BELOW ELEVATION OF TANK CONNECTION.
5. THERMOWELLS (BY MANUFACTURER).
6. CONNECTION FOR SACRIFICIAL ANODE.
7. TO AND FROM HEAT EXCHANGER AND PUMP ASSEMBLY.
8. TO SWING TANK.
9. TANK PROVIDED WITH MINIMUM R-16 INSULATION AND TOPCOAT (BY MANUFACTURER).
10. ROUTE TEMPERATURE/PRESSURE RELIEF VALVE TO NEAREST DRAIN. RELIEF VALVE TO BE MAXIMUM 110 PSI.
11. PROVIDE TANK WITH SKIRT AND SEISMIC CLIP AS REQUIRED PER LOCAL JURISDICTION (BY CONTRACTOR).
12. PROVIDE UNIONS AT EACH TANK CONNECTIONS FOR TANK REMOVAL (BY CONTRACTOR).
13. FROM DOMESTIC COLD WATER SUPPLY.
14. LOW POINT DRAIN (BY MANUFACTURER).
15. STORAGE TANKS ARE PROVIDED WITH CAPPED BOTTOM CONNECTIONS BEHIND SKIRT. CONTRACTOR TO ENSURE ALL FACTORY PROVIDED CONNECTIONS ARE SEALED WATER TIGHT BEFORE SECURING TANK.
16. ISOLATION VALVE (BY CONTRACTOR).

Below: Typical Swing Tank Detail

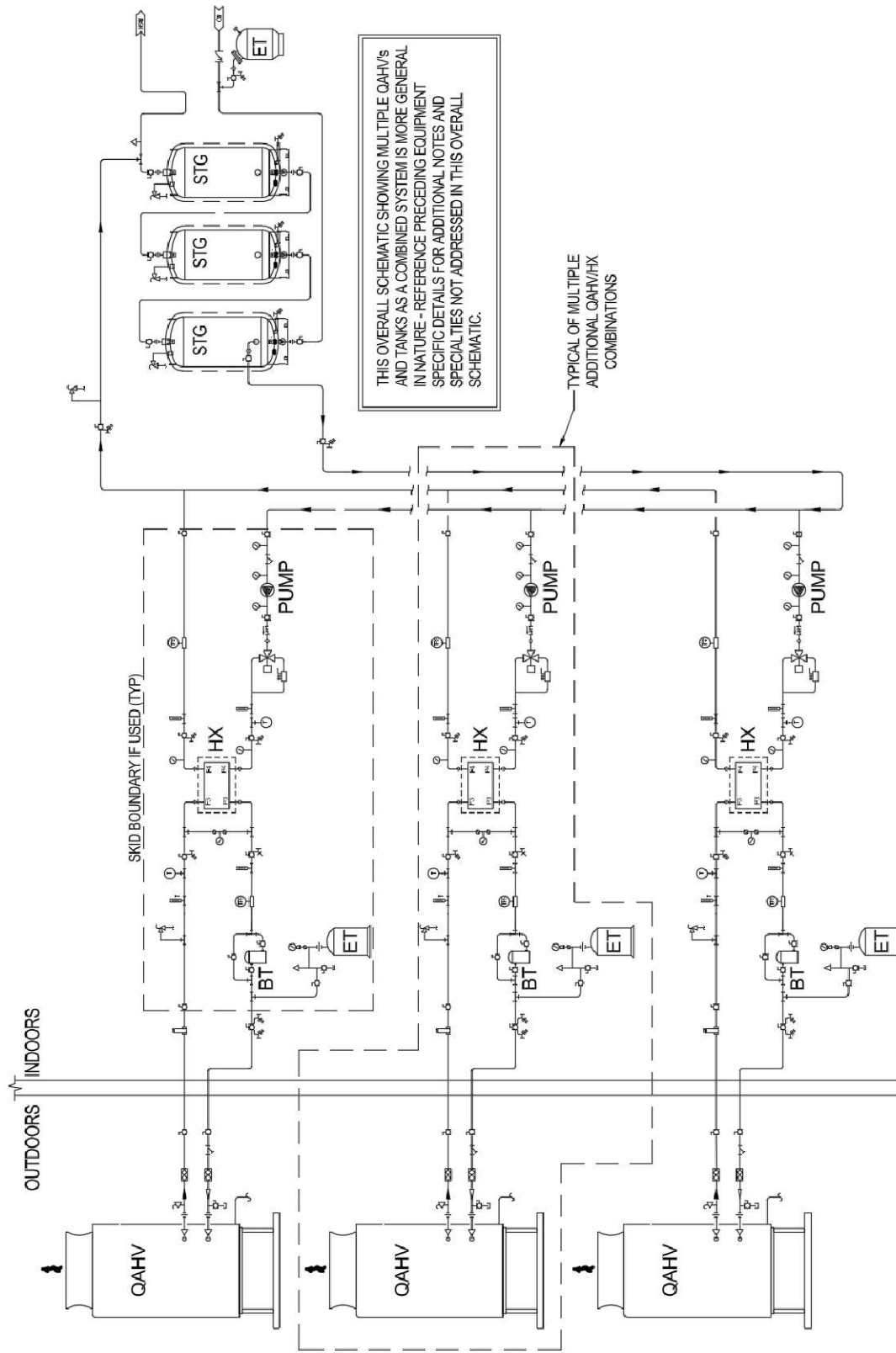


NOTE:
NOT ALL SPECIALTIES SHOWN. FINAL SIZING AND PIPING
DETAILS OF ALL DOMESTIC WATER DISTRIBUTION PIPING,
MIXING VALVE, HOT WATER RECIRCULATION PUMP AND
SYSTEM IS THE RESPONSIBILITY OF ENGINEER OF RECORD.

NOTES:

1. ELECTRONIC MIXING VALVE (BY CONTRACTOR).
2. SET BALANCING VALVE (BY CONTRACTOR) TO 25% FLOW.
3. SET BALANCING VALVE (BY CONTRACTOR) TO 75% FLOW.
4. DOMESTIC COLD WATER CONNECTION.
5. HOT WATER RE-CIRCULATION RETURN.
6. HOT WATER RE-CIRCULATION TO SWING TANK.
7. HOT WATER SUPPLY TO BUILDING.
8. HOT STORAGE WATER FROM PRIMARY STORAGE.
9. ISOLATION VALVE (BY CONTRACTOR).
10. ROUTE TEMPERATURE/PRESSURE RELIEF VALVE TO NEAREST DRAIN. RELIEF VALVE TO BE MAXIMUM 110 PSI.
11. 200°F IMMERSION TYPE THERMOMETER (BY CONTRACTOR).

Below: Scaled System Example – Multiple QAHV's



Pipe Insulation & Jacketing

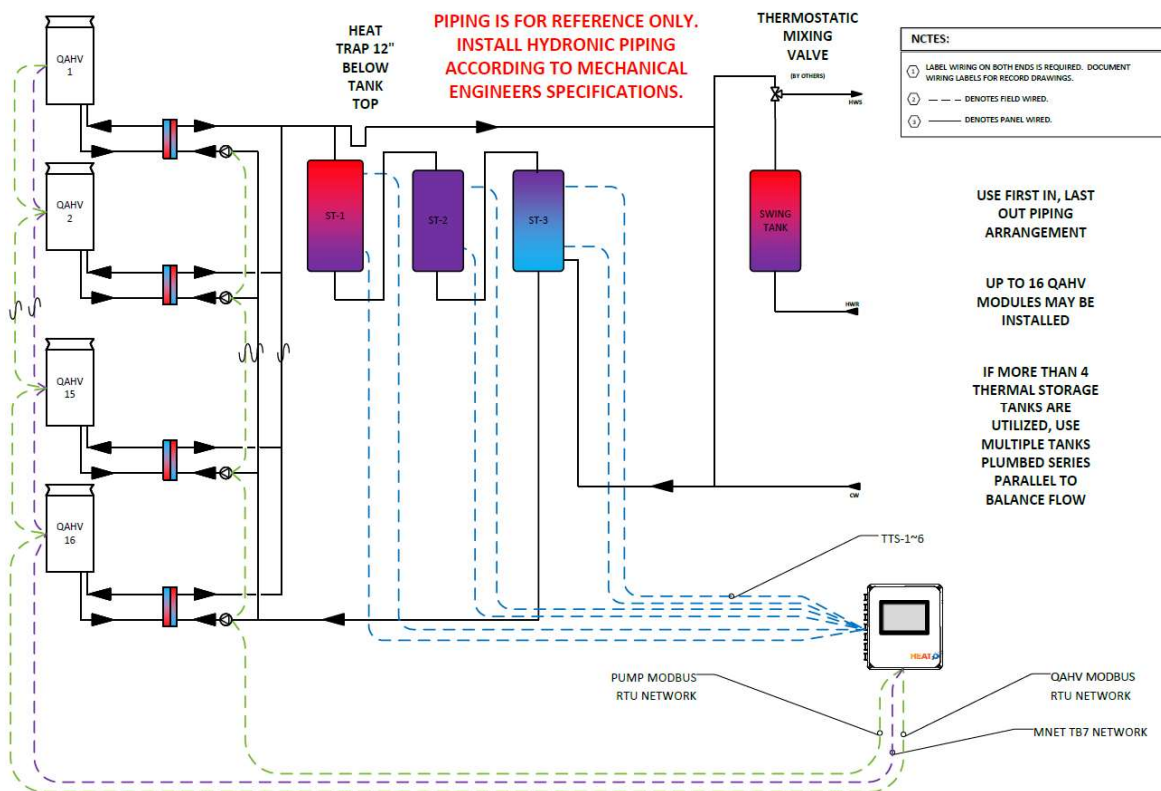
Pipe insulation should be 1-1/2" thick rated for high temperature up to 200 deg F. All water piping insulation outdoors from QAHV should be covered with protective jacketing material (preferably aluminum jackets) to protect integrity of piping insulation with all seams sealed watertight. This is especially important with cold climate freeze protection concerns. Reference freeze protection section later in this guide for additional piping freeze protection considerations.

HEAT2O CORE Control Scheme

As mentioned previously, the HEAT2O CORE expands on the original QAHV Version #1 offering but enhances thermal on/off control of the system by incorporating staging controls. Each QAHV system is configured as a master unit instead of master-sub arrangement with Version #1. In this method, the factory tank sensors and factory thermal on/off controls are not utilized as they limit the total system to single stage operations (all modules activate together).

Modbus communication is instead utilized from the main HEAT2O control panel (unique to HEAT2O CORE) allowing for simple ModBus daisy chain from all QAHV modules and associated DC pumps equipped with ModBus communication cards. This allows the system to control staging on both the QAHV's with their respective pumps when tank thermal demand is present. The DC pumps once activated via ModBus by main HEAT2O panel will thermo-regulate independently to their target water supply temperature with the pump's integral temperature controls.

Below – HEAT2O CORE Overall Wiring Schematic



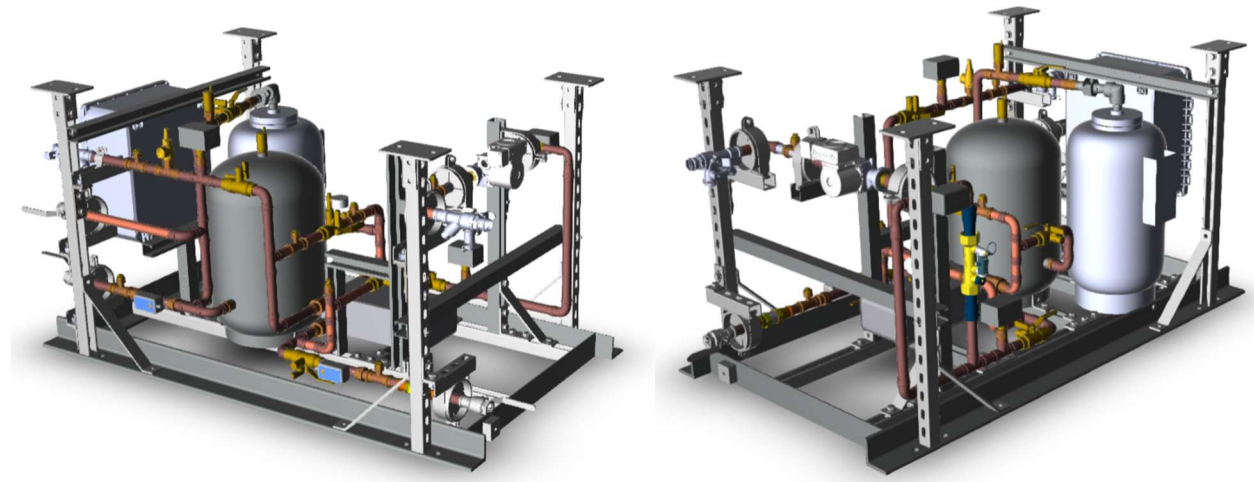
HEAT2O CONNECT (SKID) and KIT Offering and Control Scheme

HEAT2O CONNECT (SKID) Offering.

With QAHV HEAT2O CONNECT & KIT, a Skid solution (SKU: QAHVCONNECT-1) as indicated by the boundaries shown in above piping diagrams, is available to ease installation complexity for the contractor and project team. This greatly simplifies number of connections and space planning with minimal footprint. The Skid solution also allow for stacking with optional stacking legs for up to 3 skids high.

Skid Features:

- Majority of all piping specialties pre-installed (primary to secondary interface)
 - Heat Exchanger, Buffer Tank, Expansion Tank, Secondary Pump, 3-way low flow valve and balance valve, pressure relief, flush/fill valves, controls, etc....
- DC Pump with integral controls.
- Flow tracking on primary and secondary.
- Greater staging capability over basic factory controls / N+1 & Lead/Lag
- Overall size is Approx.: 62”L x 37”W x 34”H



HEAT2O KIT Offering.

The KIT (SKU: QAHVKIT-1) provides the same functionality as the skid solution with updated controls has highlighted previously, but ships to site in single package with individual components for field installation. A summary of the components provided between the KIT and SKID (SKU: QAHVCONNECT-1) is indicated below:

SKID VS KIT MAJOR COMPONENT SUMMARY							
Item	QTY	Brand	Model	SKID PACKAGE QAHVCONNECT-1	KIT PACKAGE (NO SKID) QAHVKIT-1	Ship Loose (Always)	Comments
NOTE: All Items BELOW PER QAHV							
Pump	1	Grundfos	UPMXL 25-125 N 180 VDC US 115V MSB	X	X		0-10V DC input instead of PWM
G Thread Adapter -Pump	2	Webstone	UNION, 1-1/2" Press x G1, WEBSTONE H-7-8166W-WP	X	X		
Pro-Press Reducer - Pump	2	Pro-Press	REDUCER, 1-1/2" X 1", PRESS X FTG, COPPER, # ProPress 78102	X	X		
HX	1	SWEP	BDW16DWHx81/2P	X	X		
3 Way Valve	1	Caleffi	Z307537	X	X		3/4" Sweat
3Way Valve Actuator	1	Caleffi	Z111L03 CST	X	X		24V actuator, w/end switch, NC
Balance Valve - Low Flow	1	Caleffi	132637AFC	X	X		for 0.8gpm low flow balance position of 3 way valve
Buffer Tank	1	Wessels	10 Gallon (HBT) - Part of Skid Package	X			By Others when NO Skid
Expansion Tank	1	Grundfos	10 Gallon (GNLA-35) - Part of Skid Package	X			By Others when NO Skid
Glycol Feeder	1	Axiom	DMF300-AXM or DMF150-AXM			X	Available as Separate Accessory or By Others
Relief Valve	1	McMaster Carr	8088K16	X			By Others when NO Skid (Adjustable, 3/4", 25 to 175 PSIG (25 Psig increments).
IFM Flow Meter	1	IFM	SU8621 (NSF Potable Side ONLY)	X	X		NSF RATED - For Potable Side ONLY - Measures Flow and Temp
IFM Flow Meter	1	IFM	SU8631 (Primary Glycol Side ONLY)	X	X		NOT NSF RATED - ONLY for HP Primary Side (Glycol Side). Flow Only Measurement
IFM Cable	2	IFM	CABLE, 4-WIRE, MICRO DC RIGHT ANGLE FEMALE X STRAIGHT MALE, IFM EVC015	X	X		
IFM Cable	2	IFM	CABLE, 4-WIRE, MICRO DC STRAIGHT FEMALE, IFM EVC001	X	X		
IFM IO Link Converter	2	IFM	EIO104 / (Custom model ZH4366)	X	X		Custom Part Number for Pre-programming (from IFM) - custom Part: ZH4366
Imersion Sensors w/ wells	2		A/CP-IM-2.5"	X	X		HP Primary Supply Hot Water, Secondary Cold Water Return
Skid Pannel (ISC)	1	Distech	QAHV-ISC	X	X		Includes 24VDC power supply for IFM meters

HEAT2O CONNECT (SKID) and KIT Control Scheme

For both the HEAT2O CONNECT (SKID) and KIT the controls scheme will be the same. This includes updated controls functionality to simplify setup and provide greater staging capability with N+1 redundancy if desired by design team.

Each QAHV system will comprise of the following:

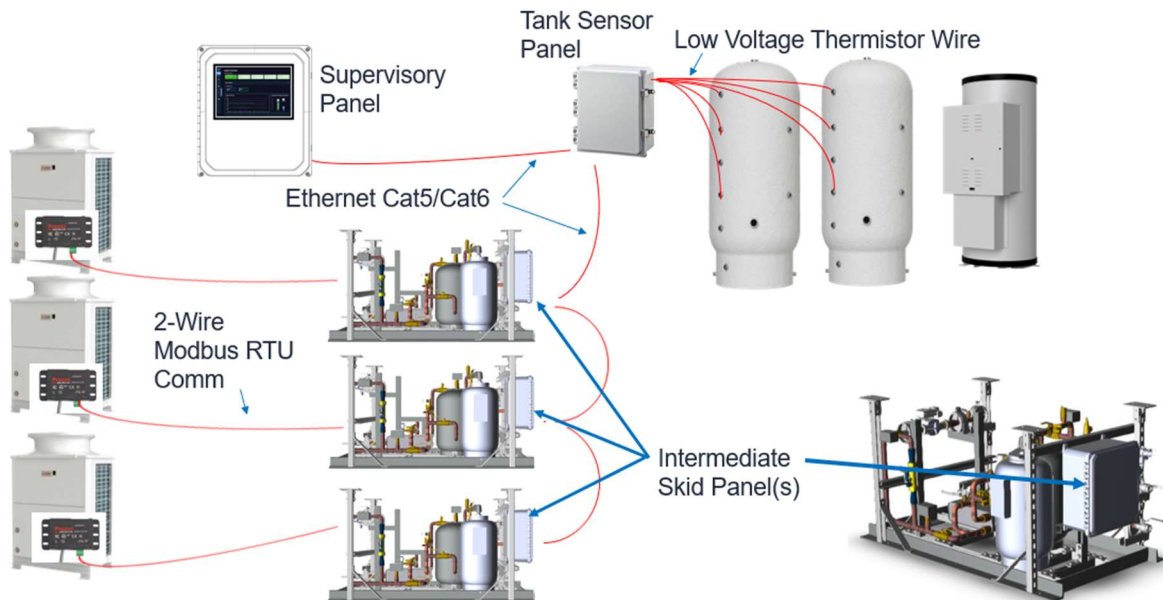
- An intermediate skid controller panel per SKID/QHAV.
- Tank temperature control panel with 3-6 Tank sensors.
- A Supervisory panel per system for integration, staging of skids, demand limiting, etc...
- An optional advanced IO panel can also be provided to pick up additional points and interlocks.

The below diagram depicts the basic controls architecture of the HEAT2O CONNECT(SKID) & KIT system. All tank temperature sensing information is relayed easily via Cat5/6 cabling to each of the skid controllers which then determine staging of that respective skid with associated QAHV.

The supervisory panel staging of QAHV's will offer two modes:

High Efficiency Mode (default) – The intermediate skid(s) are staged on incrementally. The lead skid (lowest run hours) will start first, and each additional skid(s) will start when the “On” sensor temperature continues to fall in 5°F increments from the On setpoint. The QAHV module's compressor capacity is restricted to 40kW.

High Output Mode - The intermediate skids will start simultaneously. The QAHV module's compressor capacity restriction is increased to maximum capacity.



Water Piping Freeze Protection Concerns and Recommendations.

For cold climate installations the QAHV is equipped with a freeze prevention cycle whereby the primary pump integral to the QAHV is energized per the below trigger conditions based on ambient and inlet water temperature.

Since the QAHV is only recommended for use with separation heat exchanger the compressor should be allowed to run during freeze prevention, and this must be activated by SW2-5 (below images from published manuals).

In addition, for cold climates, field provided self-regulating heat trace of exterior primary piping between QAHV, and indoor separation primary heat exchanger should be provided tied to its'

own outdoor air stat (by others) to enable the heat trace anytime outdoor ambient falls below 39F.

With all three tiers (CORE, CONNECT, KIT) of the QAHV offering for the double wall separation HX between primary and potable side, the factory has approved the use of polypropylene glycol up to 30%. It is recommended in cold climates to include this amount and do not apply glycol below this recommended percentage as it can minimize corrosion prevention and augment microbial growth. This will not provide burst protection in all cold climates however, so heat trace should still be utilized on all outdoor piping.

■ Anti-freezing operation

Pump will running to prevent from freezing

**Pump ON: Outdoor temp. $\leq 1^{\circ}\text{C}$
and Inlet water temp. $\leq 3^{\circ}\text{C}$**

**Pump OFF: Outdoor temp. $\geq 3^{\circ}\text{C}$
or Inlet water temp. $\geq 5^{\circ}\text{C}$, 3 minutes continue**

2. Purpose and application: Prevent piping freezing when the secondary side control is used

If the compressor is not run during the anti-freezing operation in the secondary side control system, there is a risk of the piping of the primary side freezing, so set SW2-5 to "ON" so that the compressor runs during the anti-freezing operation.

Setting procedure and operation overview

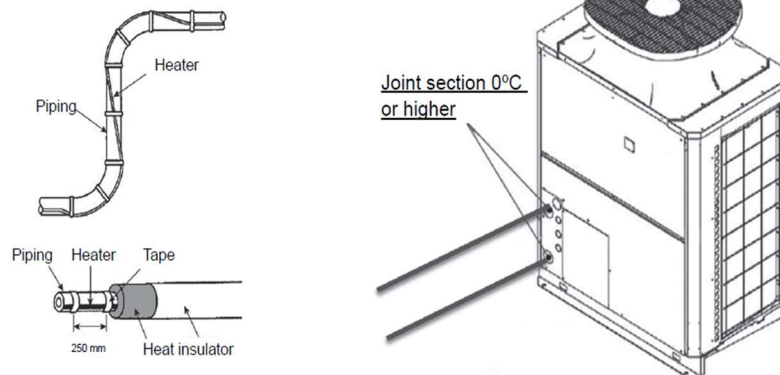
Setting procedure		Operation
SW2-5	OFF (Initial setting)	The compressor does not operate when the anti-freezing operation is performed.
	ON	The compressor operates when the anti-freezing operation is performed.

* Installing a freezing prevention heater

- ① In cold areas (where the outside temperature drops below freezing), provide a freezing prevention heater at all local pipes to prevent spontaneous freezing.
- ② After the heater is installed, check outside temperature $+25^{\circ}\text{C}$ is ensured at the heat pump unit inlet/outlet pipe joint section (at outside temperature -25°C , joint section 0°C or higher).
- ③ Depending on the local piping material, prevent overheating by selecting a self temperature adjustment type heater or other method.

Ensure $>32^{\circ}\text{F}$ Temp at -13°F

Heater installation example



Outdoor Mounting and Cold Climate Installation Requirements.

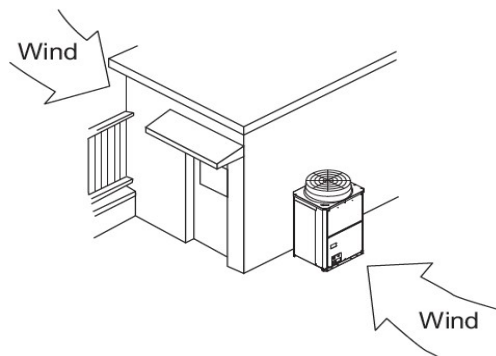
Consider mounting location vs predominant wind direction at site. Locate unit on downwind side of building structure where possible. Observe all the cold climate recommendations shown in Data Books and install literature including elevation of units above snow fall height, defrost drainage consideration, placing units with sufficient distance from roof overhands to avoid falling ice damage, consideration of discharge hoods and base pan heaters – see below from Data Book recommendations.

In addition, reference install literature for proper anchorage of mounting feet. Ensure that stands which support equipment do not have cross bracing that interferes with access to integral drain pan below unit for servicing of any field installed heat trace.

Cold Climate Installation

Observe the following when installing the units in areas where snow or strong winds prevail.

- ♦ Avoid direct exposure to rain, winds, and snow.
- ♦ Icicles that may form under the foundation can fall and inflict personal injury or property damage. Select the installation site carefully to reduce these risks, especially when installing the unit on a roof.
- ♦ If the units are installed in the direct line of rain, winds, or snow, install the optional snow hood (on both the discharge and suction ducts). Use a snow net or snow fence as necessary to protect the unit.
- ♦ Install the unit on a base approximately twice as high as the expected snowfall.
- ♦ If the unit is continuously operated for a long time with the outside air temperature below the freezing point, install a heater at the base of the unit to prevent the water from freezing at the unit bottom.
- ♦ When using the unit in an outdoor temperature of -15°C or below, install a drain pan (with heater whose capacity is 320 W or more) at the bottom surface of the unit.



- Install the outdoor unit in a place where it is not exposed to direct wind, such as behind a building.

Snow discharge hoods and intake snow/hail guards are also available for the QAHV as well. These should be used in cold climates to keep wind and wind driven precipitation off the coils as well as provide protection from hail damage. Ideally the units would be placed on downwind side of a building, but if this is not possible and snow hoods would face in upwind direction, it may be warranted to omit the snow hoods and install only the snow/hail guards on coil intake. This should also be considered for roof top installations where units would end up blowing into back of adjacent rows of units.

Below Image – QAHV Now Hood, Hail Guards, and Stand Accessories:



Please note in cold climates that supplemental heating will be required in the unit integral base pan below unit in addition to integral pan condensate outlet field piped drain to termination location. Powering, routing, and proper breaker protection of any heat trace is field provided.

Providing gutter cable/self-regulating cable with minimum wattage of 12w/ft with 3” O.C. serpentine pattern in pan to achieve the factory requirement of 320W for base pan heat. Heat trace additionally the

Below – Primary Side QAHV Water Quality Requirements:

Items		Higher mid-range temperature water system Water Temp. > 60°C (140°F)	Make-up water criteria (with secondary side control enabled) Water Temp. > 60°C (140°F)	Tendency	
		Recirculating water	Recirculating water	Corrosive	Scale-forming
Standard items	pH (25°C (77°F))	6.5 ~ 8.0	6.5 ~ 8.0	○	○
	Electric conductivity (mS/m) (25°C (77°F))	30 or less	30 or less	○	○
	(μS/cm) (25°C (77°F))	[300 or less]	[300 or less]		
	Chloride ion (mg Cl ⁻ /l)	30 or less	30 or less	○	
	Sulfate ion (mg SO ₄ ²⁻ /l)	30 or less	30 or less	○	
	Acid consumption (pH4.8) (mg CaCO ₃ /l)	50 or less	50 or less		○
	Calcium hardness (mg CaCO ₃ /l)	6.5 ≤ pH ≤ 7.5: 90 or less 7.5 ≤ pH ≤ 8.0: 50 or less	250 or less		○
Reference items	Ionic silica (mg SiO ₂ /l)	30 or less	30 or less		○
	Iron (mg Fe/l)	0.3 or less	0.3 or less	○	○
	Copper (mg Cu/l)	0.1 or less	0.1 or less	○	
	Sulfide ion (mg S ²⁻ /l)	Not to be detected	Not to be detected	○	
	Ammonium ion (mg NH ₄ ⁺ /l)	0.1 or less	0.1 or less	○	
	Residual chlorine (mg Cl/l)	0.3 or less	0.3 or less	○	
	Free carbon dioxide (mg CO ₂ /l)	10.0 or less	10.0 or less	○	

Reference: Guideline of Water Quality for Refrigeration and Air Conditioning Equipment. (JRA GL02E-1994)

For the secondary potable side of the separation HX (SWEP HX) water quality considerations and recommendations are illustrated below from the HX manufacturer literature. The designer should evaluate this with consultation of water treatment contractor and provide necessary potable side water treatment to adhere to the recommended ranges listed below.

Final treatment methods may require items such as softeners to address hardness, ion exchange to address chlorides or other methods. Such determinations are outside the scope of the QAHV equipment & package offering and are the responsibility of the design professional/engineer of record.

Below – Secondary Side (Potable Side) Water Quality Requirements, SWEP HX:

Table key	Important Note: The following parameters can also influence the corrosion resistance
+ Good resistance under normal conditions	<u>Temperature:</u> The data in the table are based water temperature of 20°C unless otherwise is stated.
0 Corrosion problems may occur especially when more factors are valued 0	<u>Presence of oxidants</u> in the environment: guidelines regarding the oxygen content are shown in Table 3.
- Use is not recommended	<u>Product form,</u> heat treatment and presence of intermetallic phases: The data in the table is based on untreated raw material.

WATER CONTENT	CONCENTRATION (mg/l or ppm)	TIME LIMITS Analyze before	Plate Material		Brazing Material		
			AISI 304	AISI 316	COPPER	NICKEL	STAINLESS STEEL
Alkalinity (HCO ₃ ⁻)	< 70	Within 24 h	+	+	0	+	+
	70-300		+	+	+	+	+
	> 300		+	+	0/+	+	+
Sulphate ^[1] (SO ₄ ²⁻)	< 70	No limit	+	+	+	+	+
	70-300		+	+	0/-	+	+
	> 300		+	+	-	+	+
HCO ₃ ⁻ / SO ₄ ²⁻	> 1.0	No limit	+	+	+	+	+
	< 1.0		+	+	0/-	+	+
Electrical conductivity ^[2] (Refer to Table 3 for oxygen content guidelines)	< 10 µS/cm	No limit	+	+	0	+	+
	10-500 µS/cm		+	+	+	+	+
	> 500 µS/cm		+	+	0	+	+
pH ^[3]	< 6.0	Within 24 h	0	0	0	+	0
	6.0-7.5		+	+	0	+	+
	7.5-9.0		+	+	+	+	+
	9.0-10		+	+	0/+ ^[4]	+	+
	>10.0		+	+	0	+	+
Ammonium (NH ₄ ⁺)	< 2	Within 24 h	+	+	+	+	+
	2-20		+	+	0	+	+
	>20		+	+	-	+	+
Chlorides (Cl ⁻) (Refer to Table2 for temperature- dependent values)	<100	No limit	+	+	+	+	+
	100-200		0	+	+	+	+
	200-300		-	+	+	+	+
	300-700		-	0/+	0/+	+	-
	>700		-	-	0	+	-
Free chlorine (Cl ₂)	< 1	Within 5 h	+	+	+	+	+
	1-5		-	-	0	+	-
	> 5		-	-	0/-	+	-
Hydrogen sulfide (H ₂ S)	< 0.05	No limit	+	+	+	+	+
	>0.05		+	+	0/-	+	+
Free (aggressive) carbon dioxide (CO ₂)	< 5	No limit	+	+	+	+	+
	5-20		+	+	0	+	+
	> 20		+	+	-	+	+
Total hardness ^[5] (Refer to "Scaling Document" for scaling aspect of hardness effect)	4.0 - 11 °dH	No limit	+	+	+	+	+
	70 - 200 mg/l CaCO ₃		+	+	+	+	+
Nitrate ^[1] (NO ₃ ⁻)	< 100	No limit	+	+	+	+	+
	> 100		+	+	0	+	+
Iron ^[6] (Fe)	< 0.2	No limit	+	+	+	+	+
	> 0.2		+	+	0	+	+
Aluminium (Al)	< 0.2	No limit	+	+	+	+	+
	> 0.2		+	+	0	+	+
Manganese ^[6] (Mn)	< 0.1	No limit	+	+	+	+	+
	> 0.1		+	+	0	+	+

- [1] Sulfates and nitrates act as inhibitors for pitting corrosion caused by chlorides in pH-neutral environments.
- [2] Electrical conductivity and Total Dissolved Solids (TDS) are connected and can be converted to each other.
- [3] In general low pH (below 6) increases corrosion risk and high pH (above 7.5) decreases corrosion risk.
- [4] In District Energy systems, due to good control over water quality, pH values up to 10 are considered safe: +
- [5] **Total Hardness/corrosion:** water with high hardness can cause corrosion problems due to its high ion content (Ca+2, Mg+2, Fe+2) which also means a high electrical conductivity as well as a high total dissolved solid (TDS). For this reason, too high hardness values should be avoided not only due to higher risk of scaling but also for corrosion risk. On the other hand, soft water, but not necessarily cation exchange softened water, may in contrast have a low buffering capacity and so be more corrosive. If the hardness values are outside the recommended range, other parameters such as oxygen content, conductivity and pH values should be considered to evaluate the corrosion risk.
- [6] Fe³⁺ and Mn⁴⁺ are strong oxidants and may increase the risk for localized corrosion on stainless steels in combination with brazing material copper.

Table 2. Maximum chloride concentrations as a function of temperature for different plate material (Data for SS-316 and are based on Outokumpus Corrosion handbook, 11th edition, 2015).

CHLORIDE CONTENT	MAXIMUM TEMPERATURE					
	20°C	30°C	60°C	80°C	120°C	130°C
= 10 ppm	SS 304	SS 304	SS 304	SS 304	SS 304	SS 316
= 25 ppm	SS 304	SS 304	SS 304	SS 304	SS 316	SS 316
= 50 ppm	SS 304	SS 304	SS 304	SS 316	SS 316	Ti
= 80 ppm	SS 316	SS 316	SS 316	SS 316	SS 316	Ti
= 200 ppm	SS 316	SS 316	SS 316	SS 316	Ti	Ti
= 300 ppm	SS 316	SS 316	SS 316	Ti	Ti	Ti
= 700 ppm	SS 316	SS 316	Ti	Ti	-	-
= 1000 ppm	SS 316	Ti	Ti	Ti	-	-
> 1000 ppm	Ti	Ti	Ti	Ti	-	-

Table 3. Oxygen concentration guide values for heating water depending on the conductivity of the water according to VDI 2035 / part 2.

Oxygen content: Corrosion reactions in water installation are determined by presence of oxygen. To avoid corrosion damage, oxygen concentrations in all parts of a water heating system should be kept as low as possible and a constant input of oxygen should be avoided. The higher the conductivity (and salt content) of the water, the lower level of oxygen is recommended to avoid corrosion.

		Low saline (low salt content)	Saline (high salt content)
Electrical conductivity at 25°C	µS/cm	< 100	100 - 1500
pH value at 25°C		8,2-10	
Oxygen	mg/l or ppm	< 0,1	< 0,02

Max Piping Distances and Elevation Difference Considerations

External losses to QAHV and elevation differential must be considered early in the design process to assess if static pressure and external operating pressure limits of the equipment will be exceeded. These limitations and how they may relate to equipment location and the number of potential floors of a building served are discussed below.

Max Piping Distance (QAHV to HX)

The internal pump in the QAHV is rated such that 60m / 196Ft is the max allowed one way piping distance from QAHV to the separation HX/Skid package. The internal pump of the QAHV is rated for approximately 10psig of external pressure head. **In general application however, it is recommended to keep this one-way distance below 175Ft. Please note this is ONLY considering water flow friction impacts and not static column effects of water based on elevation differences between the QAHV and HX.**

Storage Tank Max Pressure

The potable storage tanks provided with the QAHV package are rated to 125psig working pressure. However, designed elevation should limit operating pressures to below this. Several factors will impact the pressure at the tank including highest fixture served (static water column pressure), residual pressure required for fixture and friction losses in piping network which all must be considered in the hot water distribution system.

QAHV Max Allowable Static Pressure

The QAHV maximum static pressure is limited to 72psig (0.5Mpa). Elevation differences when QAHV is below the HX/Skid must be considered to ensure this pressure is not exceeded along with other operating pressure effects discussed below in more detail.

SWEP HX Max Allowable Static Pressure

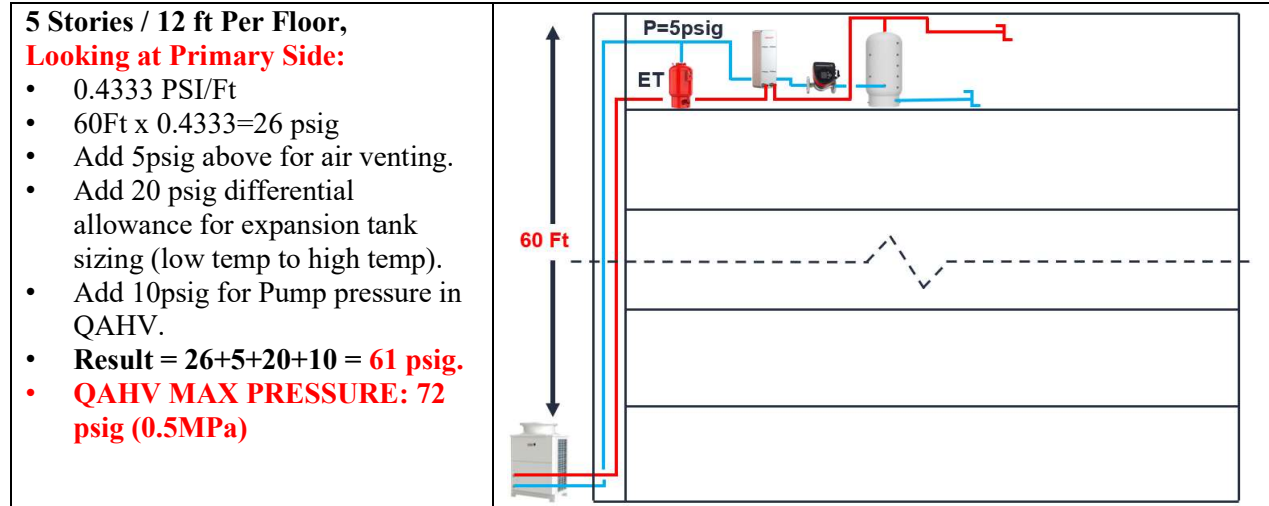
For all three tiers for the QAHV offering (CORE/KIT/CONNECT) the SWEP HX is double wall construction. Due to this, the typical issues with code requiring primary pressure to not exceed city water pressure are often eliminated (this should be verified by engineer of record for specific jurisdiction of install). With no code limitations to the primary side pressure, it is recommended to keep the max operating pressure on primary side under 125psig near the HX; however, the relationship of the QAHV to HX must still be considered and max pressure of QAHV never exceeded as stated above.

Elevation Differences QAHV Below HX/Skid

When locating only the QAHV below with Skid/HX on upper level several considerations must be made:

- Static column fill pressure due to elevation differenced from HX/Skid to QAHV.
- Pressure increases due to water expansion (correlating with pressure rise allowed in expansion tank sizing)
- Pump pressure produced internally by QAHV pump prior to exiting the QAHV which impacts pressure at fittings on discharge internally of pump.

Below is an example:

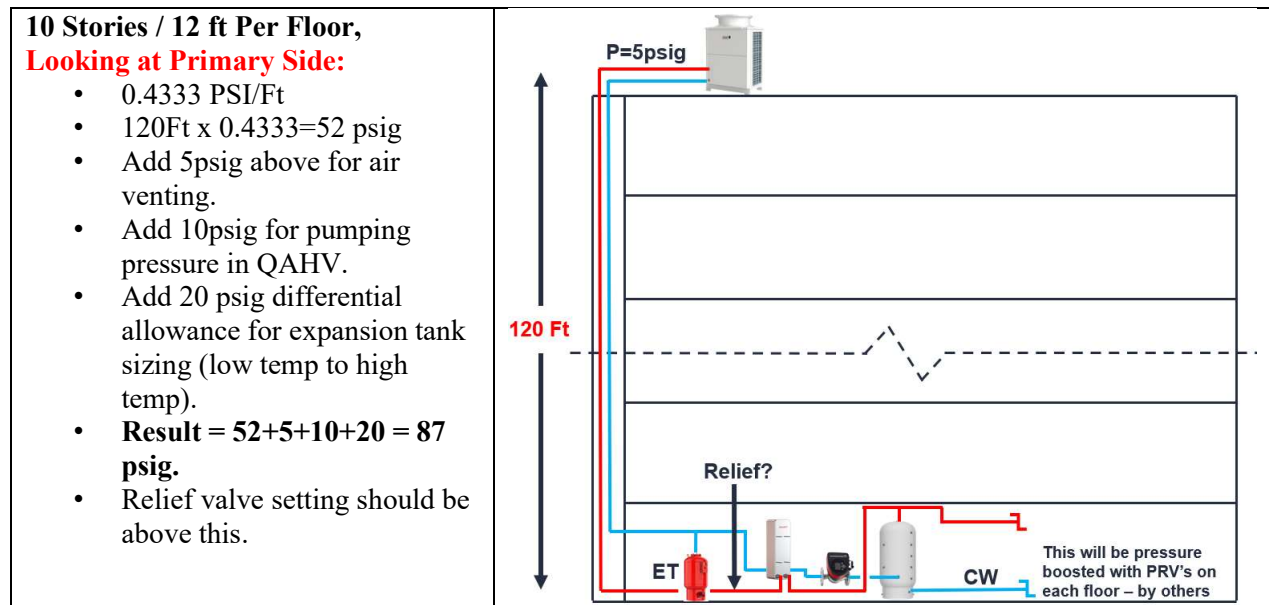


Elevation Differences QAHV Above HX/Skid

When locating only the QAHV Above with Skid/HX on lower level several considerations must be made:

- Static column fill pressure due to elevation differenced from QAVH to HX/Skid.
- Pressure increases due to water expansion (correlating with pressure rise allowed in expansion tank sizing)
- Pump pressure produced internally by QAHV pump prior to exiting the QAHV which impacts pressure at fittings on discharge internally of pump.

Below is an example:

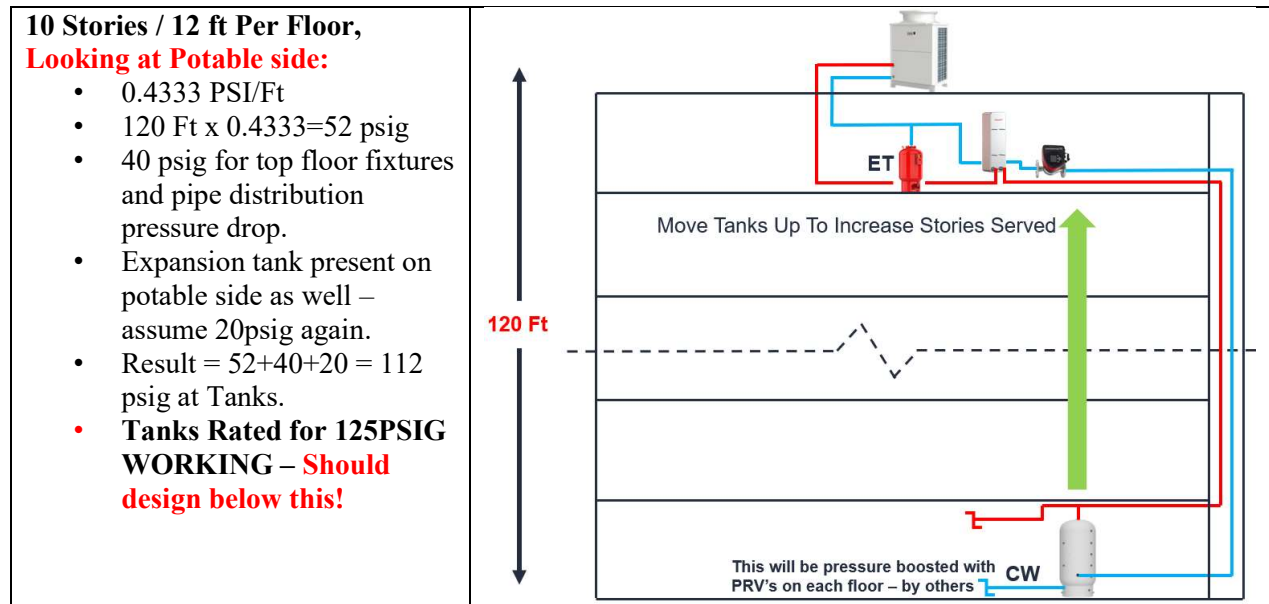


Elevation Differences QAHV & HX/Skid Above Tanks

When locating the QAHV & HX/Skid on upper level with tanks on lower level the following consideration should be made on potable side, assuming the distance is short and elevation difference minimal between QAHV and HX/Skid.

- Static column fill pressure due to elevation from top floor fixture to tanks below.
- Static pressure required for fixtures on top level as well as residual pressure for piping pressure drop when potable water is flowing.
- Pressure change due to expansion of water from cold city water temp up to maximum hot water storage temperature. This must correlate with potable side expansion tank sizing (by engineer of record).

Below is an example:



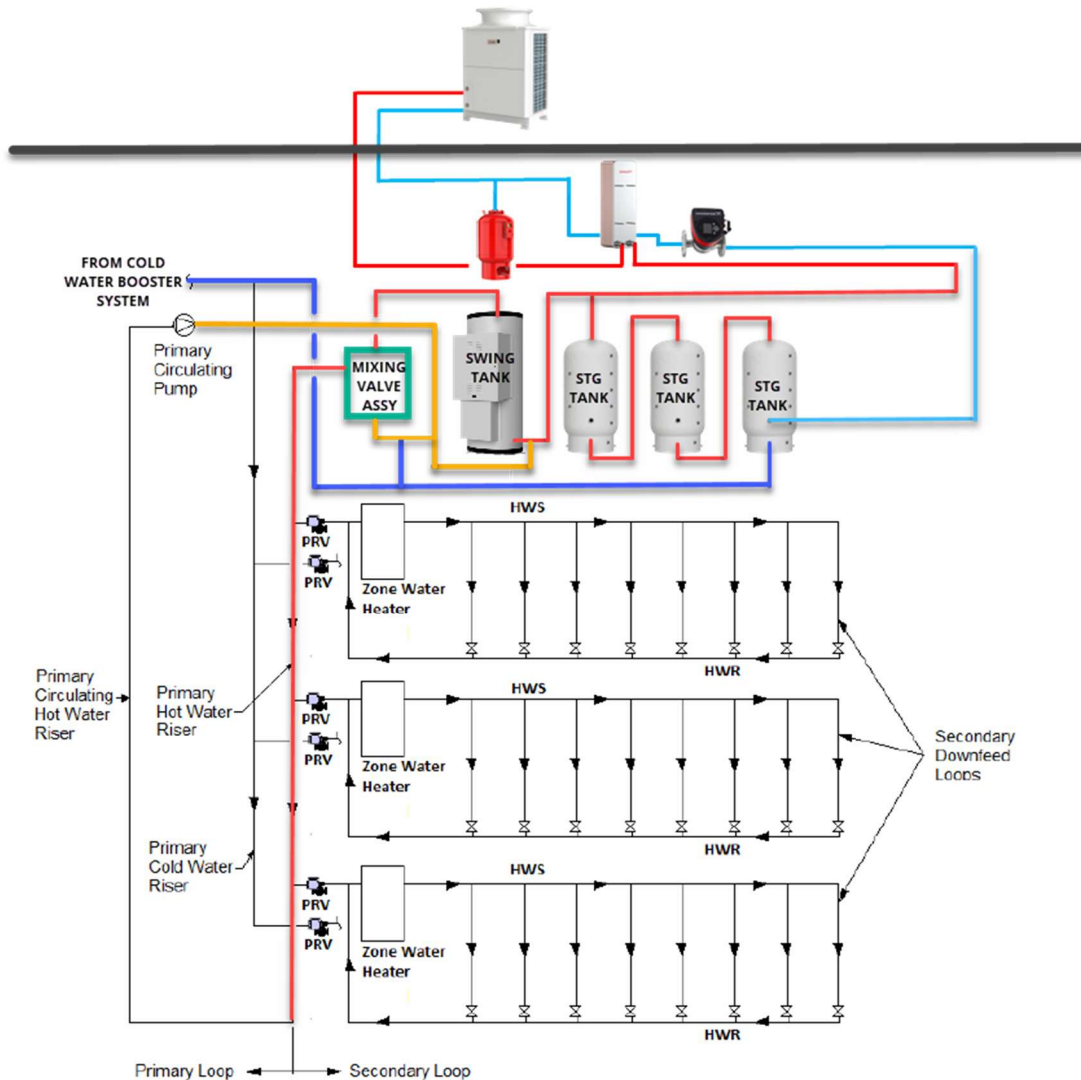
Typical High Rise Layout with >10 Floors Served

Often when number of floors served, for reasons noted above, it becomes challenging to comply with the operating pressure limitations without locating all equipment on the upper level and using a gravity down feed system with PRV's (Pressure reducing valves) on each floor to reduce pressure. Other means with creating separate decoupled pressure zones with booster pumps and separation HX's may be possible but that is outside the scope of this application guide.

Other considerations on high rise applications must be made regarding the hot water recirculation heating system when separate pressure zones are created due to static column head differences. Generally, the main system on upper level handles the main hot water generation load. In the case of a QAHV heat pump system, a swing tank on upper level may still handle the recirculation heat loss of the main riser only and then separate zone water heaters after the PRV's for each of the respective zones would handle those zone respective recirculation losses.

The full scope of this is outside the context of this application note; however, the engineer of record should consider this, as with any other high rise domestic hot water system, when breaking out pressure zones with separate hot water recirculation loops.

Below is an example:



Multiple Zone Downfeed System with Multiple Heaters & Single Main Pump

High Temperature Ambient Conditions

The QAHV is limited to 109F high ambient air conditions for guaranteed test data. Due to high operating pressure and temperatures of the CO2 high pressure side of unit it is advised to not utilize the QAHV in climates outside of the peak ambient conditions. This will lead to non-continuous operation due to high discharge temperature and pressure protection causing compressor speed limiting resulting in reduced capacity and or periodic stoppage.

Warning - Continuous operation cannot be guaranteed above 113F and abnormal shutdown as protection measure can occur above this limit.

When assessing the risk with high ambient conditions in a specific climate, referencing only the ASHRAE 0.4% Design conditions for instance would not be sufficient. Extreme annual conditions should be assessed to ensure risk of lockout is avoided – see below from ASHRAE for Dallas Fort Worth for instance. The 0.4% condition is below the 109F limit for guaranteed operation but 20 year and 50 year extremes are over this threshold.

The alternate option is to install the QAHV/s in an enclosure with separate exhaust fans and intake louvers to control the space temperature below a maximum and minimum temperature. Such enclosure requires more complex secondary controls for separate exhaust fan modulation with ambient and space temperature sensing. This is outside the scope of this document. Please reference Application note 2041 for QAHV indoor enclosure installations.

Below - Example ASHRAE Extreme Cooling Dry Bult Weather Data for Dallas Fort Worth

Prov State	Station Name	WMO	Humidification, and Enthalpy Design Conditions					
			Cooling DB/MCWB					
			0.4%		1%		2%	
			DB	MCWE	DB	MCWE	DB	MCWE
TX	DALLAS EXECUTIVE	722599	101.7	74.1	99.4	74.6	97.2	74.4
TX	DALLAS FORT WORTH INTL	722590	101.4	74.2	99.1	74.5	96.9	74.6
TX	DALLAS HENSLEY FIELD NAS	722585	99.6	75.5	97.5	75.4	95.3	75.0
TX	DALLAS LOVE FIELD	722580	101.5	74.7	99.3	75.2	97.2	74.9
TX	DECATUR MUNICIPAL	720305	99.8	70.5	97.7	70.8	95.3	71.0
TX	DEL RIO INTL	722610	102.1	71.9	100.1	72.1	98.3	72.2
TX	DENTON ENTERPRISE AP	722589	102.1	74.2	99.8	74.9	97.5	74.8
TX	DRAUGHON-MILLER CENTRAL TEXAS	722577	100.1	74.0	98.9	74.0	96.8	74.0
TX	DYESS AFB ABILENE	720965	102.4	72.0	100.1	71.8	98.0	71.7
TX	EAGLE POINT	997361	89.5	N/A	88.5	N/A	87.5	N/A
TX	EASTERWOOD FIELD	747460	100.0	75.4	98.0	75.6	95.9	75.5

Extreme Annual Design Conditions																
Prov State	Station Name	Extreme Annual	Extreme Annual DB				n-Year Return Period Values of Extreme DB									
			Mean		Standard Deviation		n=5 years		n=10 years		n=20 years		n=50 years			
			5%	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
TX	COX FIELD	18.8	14.4	101.0	3.8	4.2	11.7	104.1	9.5	106.6	7.4	108.9	4.7	112.0		
TX	CURTIS FIELD	17.6	15.8	102.4	3.6	3.6	13.2	105.0	11.1	107.2	9.1	109.2	6.5	111.9		
TX	DALHART MUNICIPAL AP	23.7	1.1	102.7	4.9	2.8	-2.5	104.7	-5.3	106.4	-8.1	108.0	-11.7	110.0		
TX	DALLAS EXECUTIVE	17.5	18.0	104.4	3.2	3.3	15.7	106.8	13.8	108.7	12.1	110.6	9.8	113.0		
TX	DALLAS FORT WORTH INTL	20.6	17.9	104.1	4.0	3.5	15.0	106.6	12.7	108.6	10.5	110.6	7.6	113.1		
TX	DALLAS HENSLEY FIELD NAS	17.0	18.1	103.1	7.5	2.6	12.7	105.0	8.3	106.5	4.1	108.0	-1.4	109.9		
TX	DALLAS LOVE FIELD	18.7	19.1	104.4	3.9	3.0	16.4	106.6	14.1	108.3	11.9	110.0	9.1	112.1		
TX	DECATUR MUNICIPAL	17.9	15.9	102.9	4.9	2.8	12.4	104.9	9.5	106.5	6.8	108.1	3.2	110.1		
TX	DEL RIO INTL	16.9	24.7	105.9	3.5	2.6	22.2	107.8	20.2	109.4	18.2	110.9	15.7	112.8		
TX	DENTON ENTERPRISE AP	19.3	13.8	104.6	3.9	3.3	11.0	107.0	8.7	108.9	6.4	110.7	3.6	113.1		
TX	DRAUGHON-MILLER CENTRAL TEXAS	20.1	18.3	103.8	3.9	5.0	15.6	107.3	13.3	110.3	11.1	113.0	8.3	116.7		
TX	DYESS AFB ABILENE	21.1	12.8	105.4	4.6	2.9	9.5	107.5	6.8	109.2	4.2	110.8	0.8	112.8		
TX	EAGLE POINT	23.1	31.1	92.9	4.3	2.3	28.0	94.5	25.5	95.8	23.1	97.1	20.0	98.7		
TX	EASTERWOOD FIELD	16.8	23.1	103.1	3.6	3.2	20.5	105.4	18.4	107.3	16.4	109.2	13.8	111.5		