

Application Note 2014: City Multi PWFY HEX & Booster Units

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Introduction

This document is a general application guide for the Mitsubishi Electric CITY MULTI refrigerant to water heat exchanger products or PWFY line of equipment. This document is to serve as a supplement to the technical data already contained within the Mitsubishi CITY MULTI Engineering Manuals, Submittal Sheets, and other service, operation and installation manuals.

This Document will cover the general application of the following products:

HEX Unit: PWFY-P36NMU-E-AU (3 Ton Nominal)
HEX Unit: PWFY-P72NMU-E-AU (6 Ton Nominal)
Booster Unit: PWFY-P36NMU-E-BU (3 Ton Nominal)

What Is the HEX (PEFY-*-E-AU) Unit?

The HEX unit, as shown in Figures 1 and 2, is a refrigerant to water heat exchanger. It can cool (absorb heat) or reject heat to/from the water loop it is connected to.

It is different from other types of refrigerant heat exchangers in that it can be connected to the CITY MULTI variable refrigerant flow system with other indoor units, in which case it has the same demand and ability to utilize the VRF system capacity just as any other indoor unit on the system.

In many cases the same allowance for total nominal connected capacity still apply when the HEX unit is installed on a system with other indoor fan coils.

The HEX unit can also be the only indoor device on the VRF system as well but with only 100% allowable connected nominal capacity.



Figure 1. HEX Unit

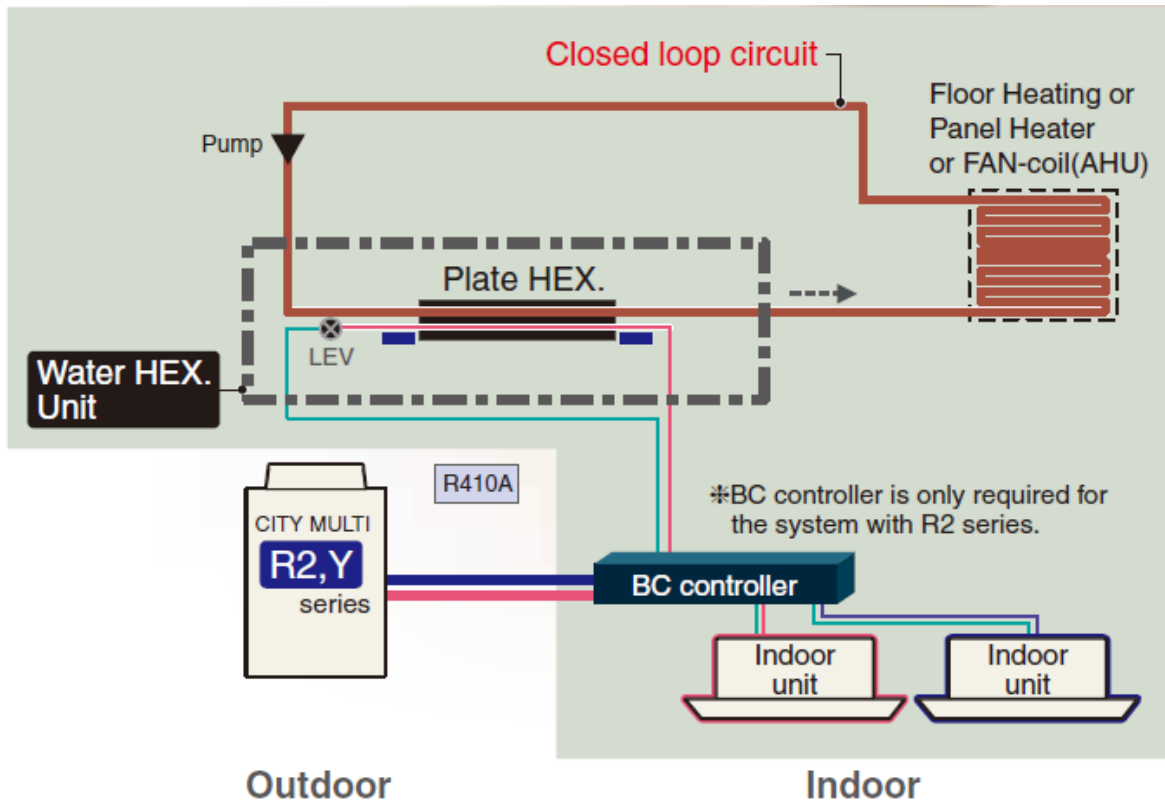


Figure 2. HEX Unit General Schematic

What Is the Booster (PEFY-*-E-BU) Unit?

The booster unit shown in Figures 3 and 4 is similar to the HEX unit, still acting as a heat exchange device between the VRF R410a refrigerant loop and a water loop. However, the booster unit also contains a secondary R-134a refrigerant loop with a secondary compressor that allows the unit to produce warmer water.

The booster unit, unlike the HEX unit, can NOT provide cooling for the water loop it is connected to, since the R-134a loop does not contain a reversing valve.

As with the HEX unit, it can be connected to the VRF system with other indoor units or as the only device connected to the system with similar limitations.



Figure 3. HEX Booster Unit

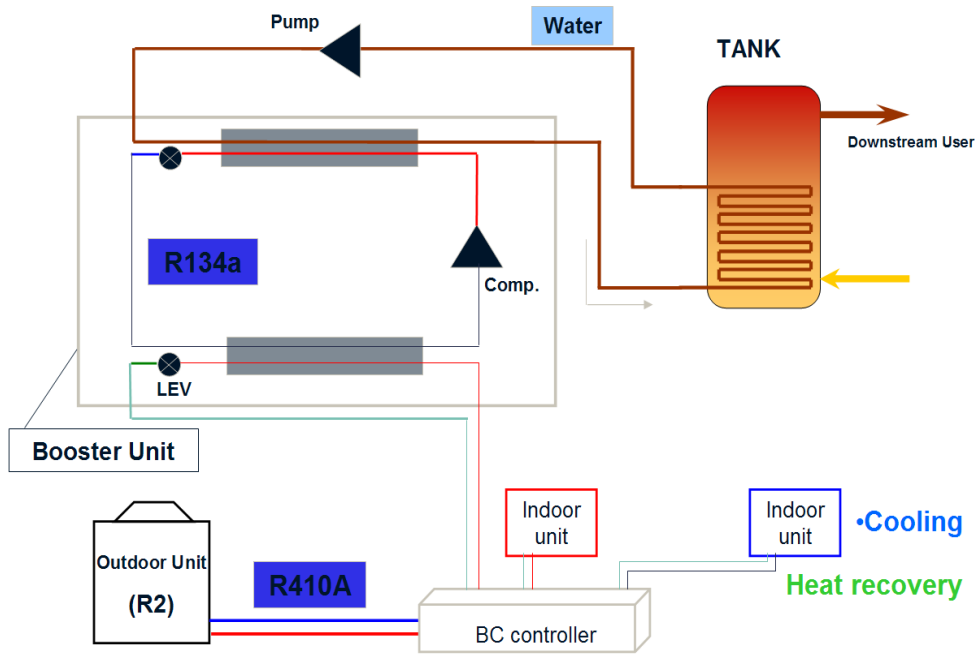


Figure 4. Booster Unit General Schematic

VRF SYSTEM INTEGRATION

System Compatibility

As illustrated in the previous section and in Table 1 and Figure 5, the HEX unit and Booster unit are connected to the VRF system just as any other indoor fan coil unit. The HEX and Booster units both can be integrated with the CITY MULTI R2 system; however, only the Hex unit can be connected to the Y-Series equipment. The below table summarizes the compatibility.

Table 1. HEX Unit System Capability

HEX Unit Compatibility	Booster Unit Compatibility
Modular R2 Series – Air Cooled Modular Y Series – Air Cooled (Including Hyper Heat) Modular WR2 – Water Cooled Modular WY – Water Cooled	Modular R2 Series – Air Cooled Modular WR2 – Water Cooled

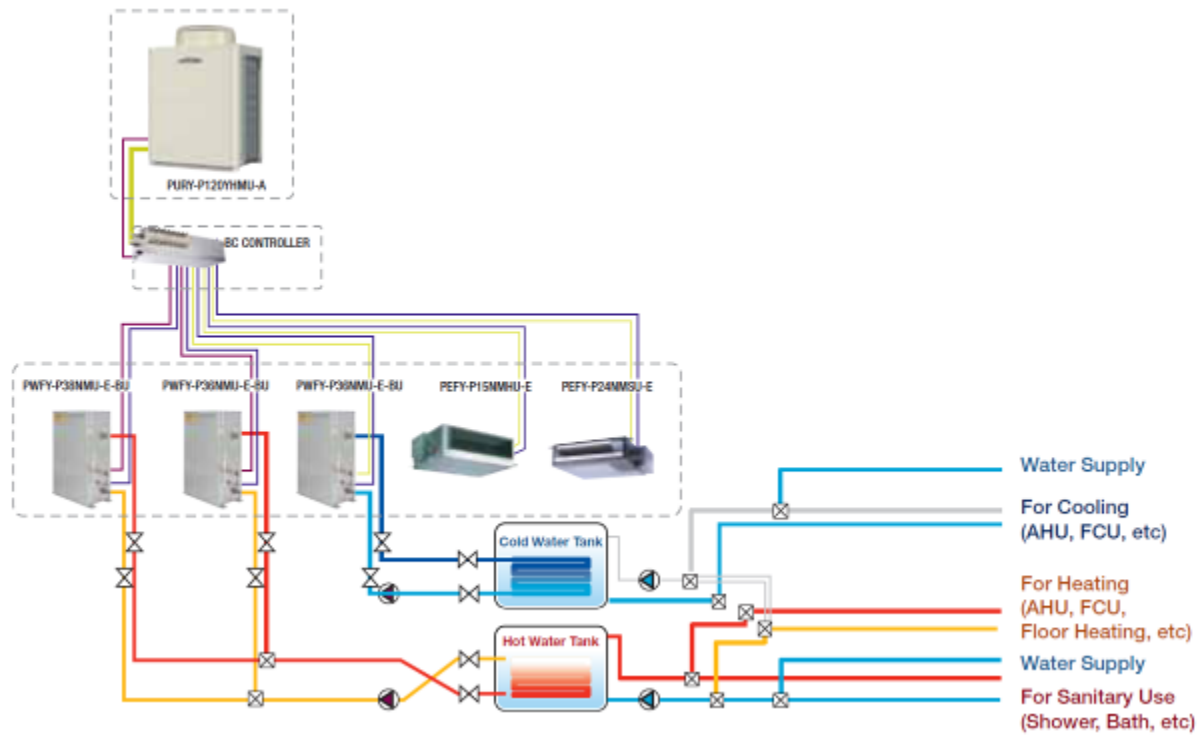


Figure 5. System Integration Sample Schematic

Connected Capacity w/ HEX & Booster

The HEX and Booster unit have the same demand priority on the system as any other indoor unit. In essence they share load with other indoor units and the capacity of the HEX and Booster unit will be affected by connected diversity just as any other indoor unit.

When designing a VRF system that includes the HEX and Booster unit Diamond System Builder should always be used, just as with any other traditional VRF design, to accurately assess the de-rates and other effects of connected capacity. This will be especially true for heating dominant applications where the HEX or Booster is expected to provide heat during periods when other VRF indoor fan coil units are calling for heat.

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Table 2 below lists some basic guidelines for connected capacity on R2 systems given different design cases. This is in no way all inclusive of every instance, and Diamond System Builder should always be used to verify performance. Further detail of potential target applications will be described later in this paper.

Table 2. Guidelines for Connected Capacities on Heat Recovery Systems

System Type	Application Description	Climate Type	Primary Water Function	Rec. Max Connected Capacity
R2	Year Round Cooling Dominant Load such as Casino	Any Climate Type	Additional Hot Water for Domestic Use	150 %
R2	Year Round Cooling Dominant Load such as Casino	Cold Climate	Hot Water for Snowmelt	150 %
R2	Commercial Building	Cold Climate	Radiant Heating/Hot Water Reheat Coils	100%
R2	Gym/Workout Area (Cooling Dominant)	Hot Climate	Pool Cooling	100 %
R2	Gym/Workout Area (Cooling Dominant)	Cold Climate	Pool Heating	150 %

Table 3 lists the hard threshold restrictions for total connected capacity when applying the HEX and Booster unit.

Table 3. Connectable outdoor unit capacity range for PWFY combination

System Type	Only PWFY	PWFY with standard indoor unit	Only standard indoor units	Connectable PWFY Type
R2-Series	50-100%	50-150%	50-150%	BU, AU
Y-Series	50-100%	50-130%	50-130%	AU

DESIGN CONSIDERATION

There are a few key factors that should be considered and addressed before utilizing the HEX or Booster Unit for hydronic heat exchange applications. These are summarized below.

Modes & Hydronic Temperature Ranges Available

The HEX and Booster units each offer specific operational modes with specific adjustable temperature ranges. These modes are summarized below in Tables 4 and 5.

Table 4. HEX Unit Modes

Mode	Comments
Heating	Control heating water loop from 86°F to 113 °F (50 to 105 °F Entering Water Temp Range)
Heating Eco	Automatic reset of hot water temp based on o/a temperature.
Anti-Freeze	Maintain water loop temp above freezing
Cooling	Produce cooling water down to 41 °F (when sensing at inlet water - Min inlet temp of 50 °F) Note: Lowest Control Set point is 50 deg F.

Table 5. Booster Unit Modes

Mode	Comments
Hot Water	Boost heating water up to 160 °F (50 to 160 °F Entering Water Temp Range)
Heating	Control heating water loop Up to 122 °F
Anti-Freeze	Maintain water loop temp above freezing

Potable Water Applications

Neither the HEX or Booster units are potable rated. Because of this, most codes and jurisdictions will require the use of a secondary heat exchanger between the water loop connected to the HEX or Booster and the potable water source exchanging heat with this system. Some jurisdictions or local codes may even require that this heat exchanger be of a double containment construction, such that a leak event does not result in contamination of the potable water source.

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Closed Loop Application Only

Both the HEX and Booster unit are designed for closed loop heat exchange applications. Connections to any other open loop systems (such as domestic water) should be handled via a secondary heat exchanger.

The closed loop system serving the HEX or Booster unit/s should also be chemically treated with corrosion / rust inhibitors, have balanced PH, and include air separation/removal and water expansion devices to ensure integrity and performance of the refrigerant to water heat exchangers.

Since these units are intended for closed loop applications, circulation pumps must be used to circulation the closed loop heat exchange fluid through the unit. Consideration of pressure drop and flow ranges through these devices must be considered in addition to other losses on the closed loop piping to properly size the circulation pump.

Figure 6 shows a sample pressure drop chart – consult the PWFY Engineering Manual for additional charts pertaining to pressure drop and other de-rates.

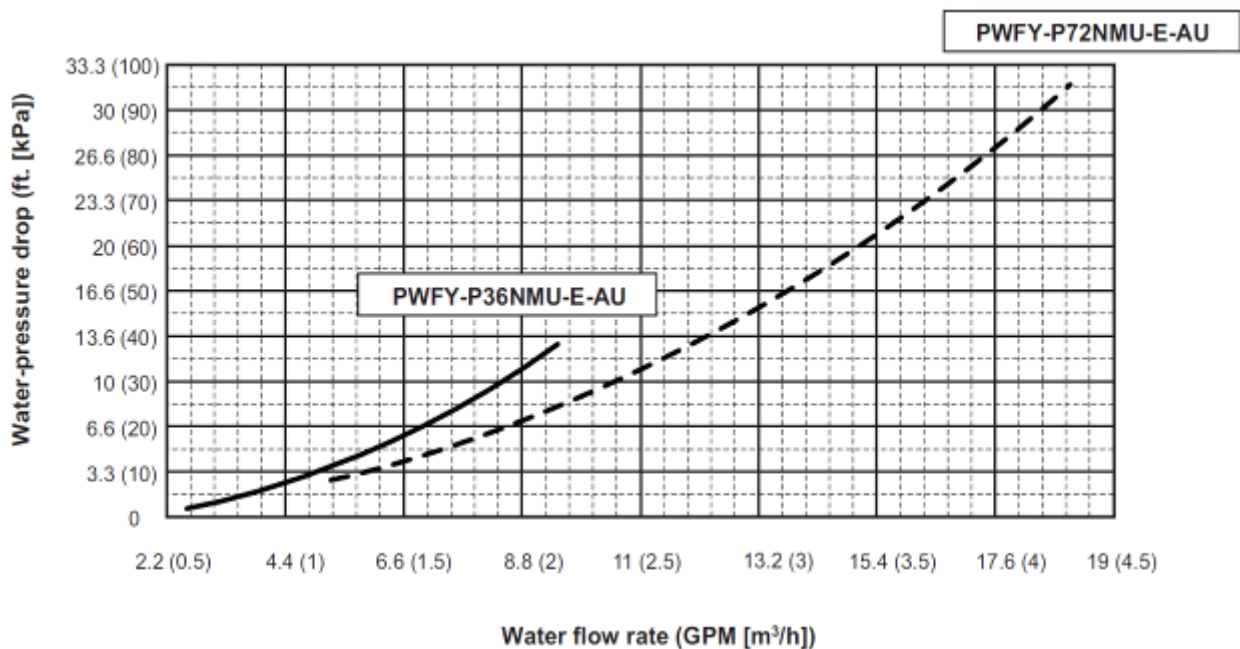


Figure 6. Sample PWFY Pressure Loss vs. Fluid Flow Chart

Flow range for HEX (PWFY-P36NMU-E-AU): 5 – 9 GPM
Flow range for HEX (PWFY-P72NMU-E-AU): 8 – 18 GPM
Flow range for Booster (PWFY-P36NMU-E-BU): 3 – 9 GPM

Consideration of HEX Unit Hydronic Loop Temperatures.

The HEX unit will experience a de-rate similar to other indoor fan coil units during low ambient conditions. For instance, if the VRF system is operating in a “heating main” mode at low ambient conditions, the refrigeration system high side temperature and pressure will begin to fall below a certain ambient temperature, and thus the temperature achieved by the HEX unit in heating mode on the closed loop hydronic side would decrease as well.

For this reason, it is recommend to not rely on the HEX unit for critical heating temperature control applications but rather utilize the unit for heat recovery purposes to unload the primary heat source for the hydronic system it serves. Applications suggestions will be discussed later in this paper.

Diamond System Builder, along with the PWFY Engineering Manual, can be used to access de-rates during lower ambient conditions.

HEX Cooling and Low Ambient Considerations

When using the HEX unit for cooling water applications especially with air cooled equipment it is required to include glycol for freeze protection to at least -4 deg F in the water circulating through the HEX. The HEX is equipped with a brazed plate heat exchanger and potential loss or abrupt loss of flow due to pump failure while HEX is fully loaded during HEX cooling operation poses a potential freezing risk.

During ambient temperatures below 32 deg F if the HEX unit is not being utilized, especially when connected on an City Multi R2 air cooled system that is running in heating main mode, it is important to also maintain water circulation through the HEX unit even when not thermally active.

Alternately, if the HEX is not being used during winter months and glycol and continuous pump circulation is not provided, the unit can be shut down and water drained from the heat exchanger as a preventative measure.

In general glycol is encouraged in all applications to minimize potential heat exchanger freezing risk in the event proof of flow protections fail or are damaged. Freezing at the heat exchanger can lead to catastrophic failure of the entire refrigerant system.

WARNING: the HEX unit with firmware version 1.13 or later will utilize the HEX to capture heat from water source heat sink for outdoor unit defrost even if the HEX is commanded off and pump is stopped. Flow proving input contacts will also be ignored during this time. For this reason if pump is not run continuously it is required to provide an additional pump interlock via TB141A-OUT1 to force pump to run when HEX is on during outdoor unit defrost.

Minimum Piping Provisions at Unit

The units are equipped with brazed plate heat exchangers. These heat exchangers have multiple plates with small passages and as such are prone to partial clogging of debris/contaminants in system during initial flushing and debris arising over long term deterioration of piping systems in buildings.

APPLICATION NOTES

As such, a greater than 50 mesh strainer is required immediately at inlet connections of the water source modules. Failure to follow this may result in reduced flow, heat transfer, higher operating head pressure on refrigerant circuit, and resulting compressor power / energy use penalties.

The below diagram illustrates some of the basic provisions that should be provided at each water source module:

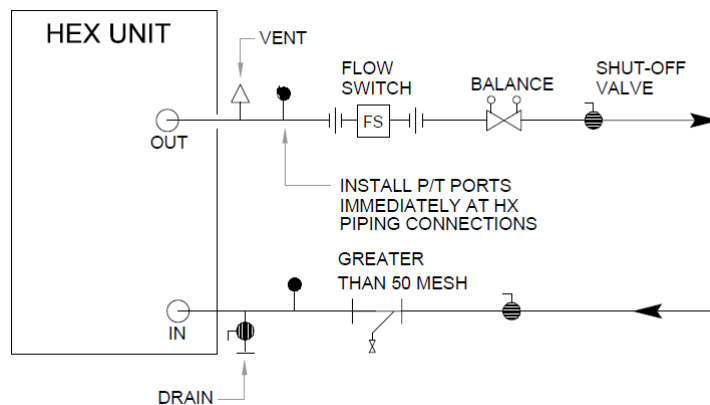


Figure 7. Minimum Piping Provisions At HEX

Minimum Size Buffer Tank / Short Cycle Protection

For all applications of the HEX, regardless of inclusion in backup heat, a minimum size buffer tank should always be provided in the water loop to prevent short cycling / low load stability issues in the HEX unit operation. The buffer tank shall be a minimum of 26.4 US gallons (100 Liters). Failure to include this may lead to poor temperature control performance of hydronic loop temperatures, specifically at low load.

Consideration of Defrost Cycles & Increased Buffer Tank Size

When the HEX or Booster is coupled with air source equipment, especially if no back up heat system on the hydronic loop is provided (not generally recommended), consideration of intermittent loss in heating output due to outdoor unit periodic defrost should be considered. Failure to consider this can lead to drop in hydronic loop temperature and poor hydronic loop heating performance.

Defrost periods can last up to 12 minutes depending on outdoor conditions and system loading. Especially for small hydronic loops, sufficient water volume and residual heat in hydronic piping may not be available to allow completion of the defrost cycle. This can be especially true for air cooled VRF systems that are only connected to HEX units with no other standard indoor fan coils. Due to this in many cases the inclusion of a larger buffer tank in the hydronic loop to cover the defrost period is warranted.

Also when the HEX is applied in 1 to 1 applications with outdoor air cooled equipment, the loop through the HEX should be maintained at 80 deg F or above to facilitate defrost. The HEX will not be able to utilize the water loop for defrost unless water loop incoming temperature is at

APPLICATION NOTES

least above 64 deg F. This is especially important on smaller 1 to 1 applications of the HEX where refrigerant piping is minimal.

When sizing the larger buffer tank for defrost periods, it is recommended to base the volume capacity on the full pump design flow serving the HEX unit for the maximum defrost duration. The image below depicts a generalized piping schematic utilizing a buffer tank:

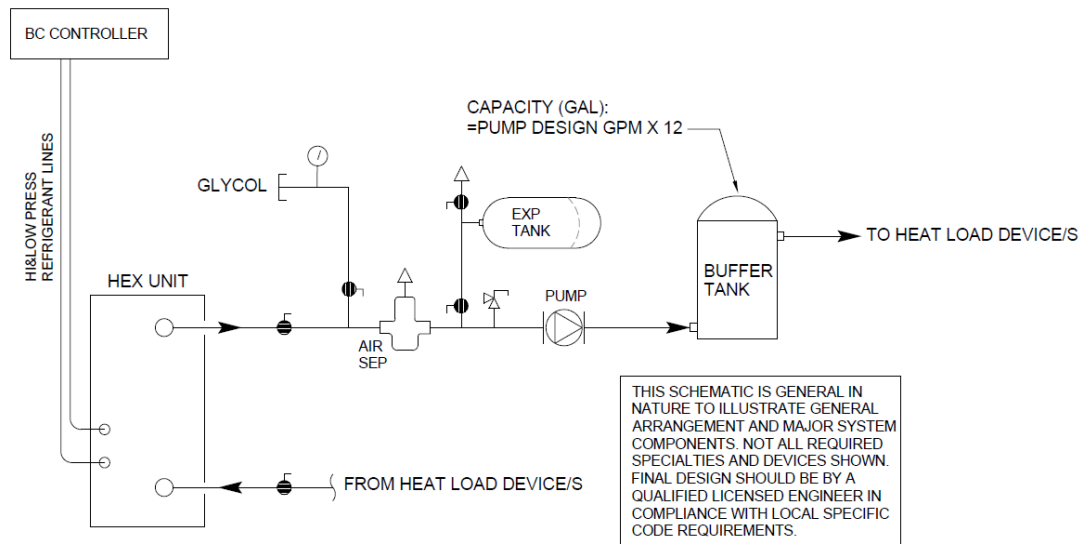


Figure 8. Utilizing a Larger Buffer Tank to Cover Defrost Periods

Controls

The Hex and Booster unit will have CITY MULTI integrated controls from the factory that will automatically control the operation of the HEX or Booster unit including the LEV or linear expansion valve on the unit as well as the secondary compressor operation on the Booster unit. These controls will also integrate the HEX or Booster unit into the CITY MULTI M-Net control network.

The standard offering for these units includes the use of a CITY MULTI (PAR-W21MAA-J) wall remote controller which will allow for mode adjustment and set point temperature adjustment of the heat exchange loop the HEX or Booster unit is coupled to.

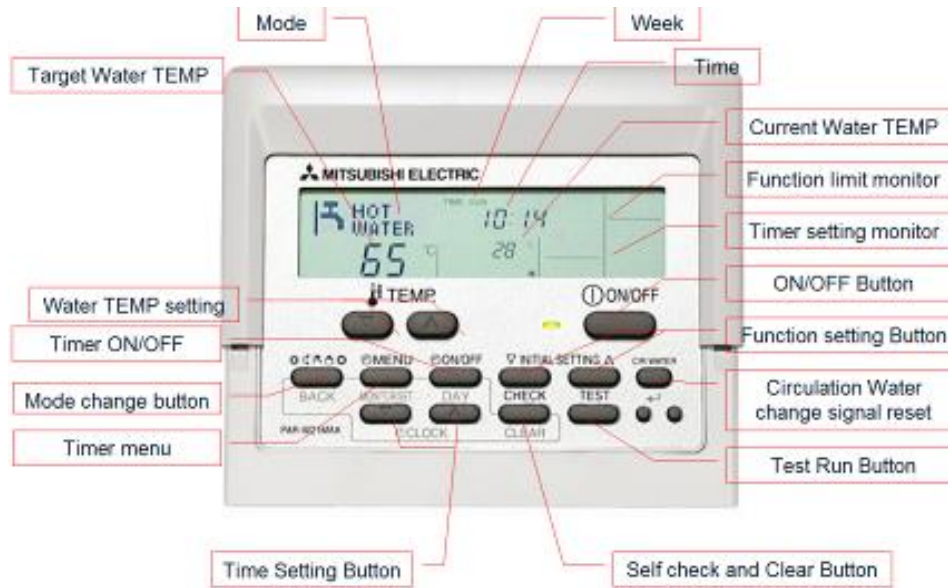


Figure 9. Illustration of PAR-W21MAA-J Functions

Some of the basic points available on the control boards integral to the HEX and Booster Unit are listed in Table 6.

Table 6. Basic Points on the Integrated Control Board

Inputs Signals Available	Output Signals Available
Operation Signal (On/Off) Operation mode (Cooling) Operation mode (Heating) Operation mode (Heating Eco) Operation mode (Ani-Freeze) Demand (On/Off) Pump Interlock Water Temperature Setting (4-20mA)	Operation (On/Off) Error Defrost

Control of ancillary components and monitoring of other hydronic loop attributes connected to the HEX or Booster unit, will require additional field installed controls. Examples would be secondary hydronic loop pump start / stop, pump differential pressure monitoring, additional flow monitoring, secondary loop temperature monitoring, control valve modulation, etc.

TARGET APPLICATIONS

Domestic Hot Water Pre-Heat (HEX Unit)

A largely anticipated application of this product would be for heat recovery applications for pre-heating of domestic hot water. This would be especially true for a VRF system with a year round cooling dominant profile, where a connected capacity of up to 150% on an R2 system would have lesser effect on cooling performance of the other indoor fan coil units compared to the heating effect on fan coils in a heating dominant / load driven system.

This could also be applied to the Y-series equipment, but the economics of providing it with regard to the effect on the outdoor unit size due to lesser allowed connected capacity / diversity without heat recovery opportunities may prove cost prohibitive.

This application could involve a single HEX unit or several HEX units from multiple VRF systems. The economics of this should be evaluated by the engineer / designer for each project.

Consideration of the peak domestic hot water draw is an important factor for this application. This is typically part of any traditional domestic hot water heater design, so the plumbing designer / engineer, should be able to evaluate the peak draw on the system.

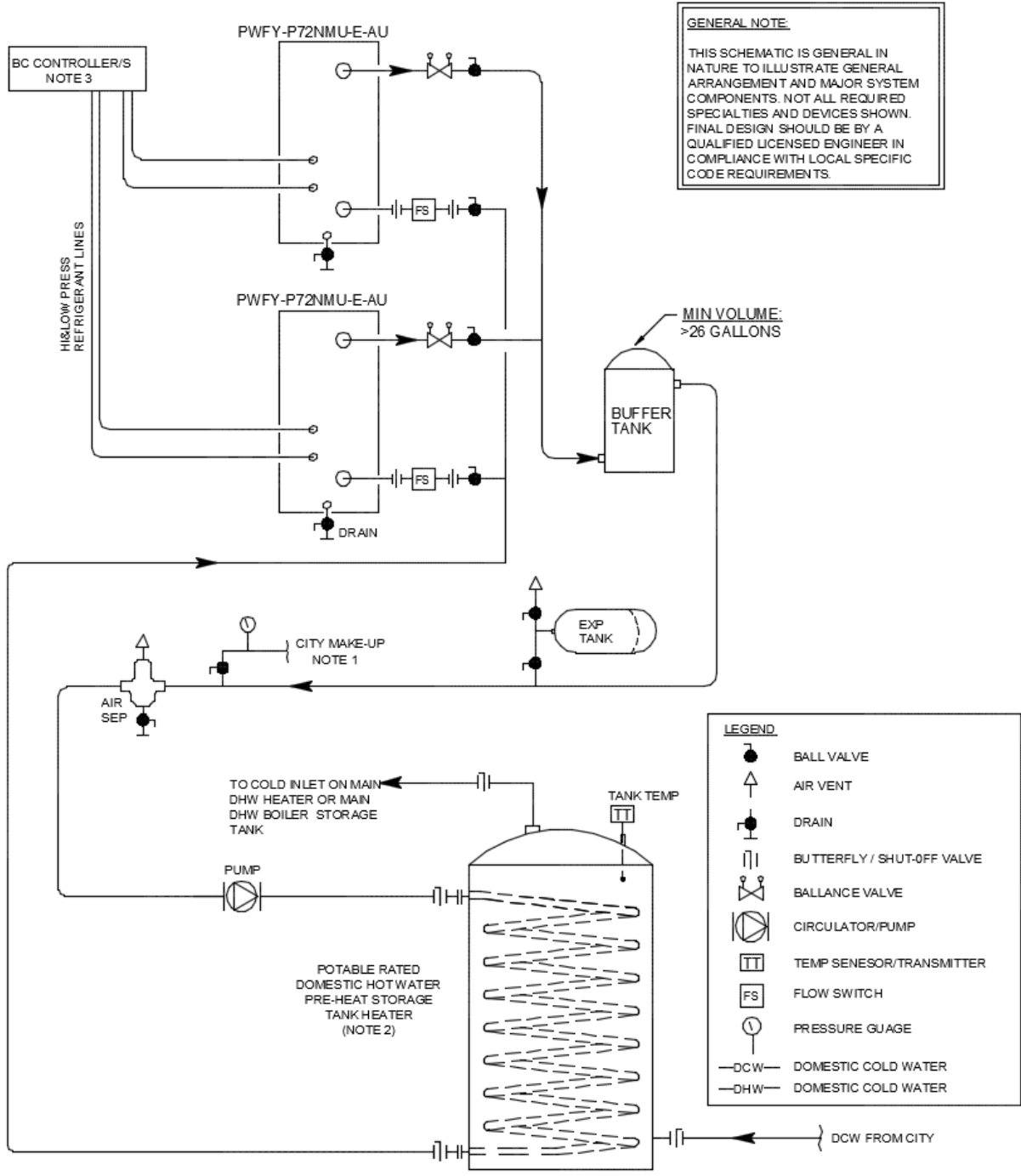
In considering the peak domestic hot water draw, the selection of the primary domestic hot water heating system can be determined. Typically the capacity of the hot water heater can be adjusted based on the amount of hot water storage used in conjunction with the peak heating rate of the domestic hot water heater. ASHRAE and other sources provide guidance for this and this topic will not be covered in this paper.

What is important, however, is to try and match the storage capacity of the primary domestic hot water heating system with a pre-heat storage volume that is connected to the HEX unit/s. In this way the pre-heat storage tank will directly unload the primary domestic hot water heater storage tank. This will reduce the primary hot water heater total energy usage associated with recovering the primary storage tank after a peak use period.

If the capacity available (from HEX units feasibly implemented on the project) is not sufficient to recover the pre-heat storage tank in a time frame similar to what is anticipated for the primary water heating system storage tank, then consideration of a smaller pre-heat tank storage volume may be warranted.

Figure 10 illustrates the application of this product for domestic hot water pre-heat applications.

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NOTE 1: FROM CITY MAKE-UP WITH BACK-FLOW PREVENTION DEVICE PER LOCAL CODES.
 NOTE 2: LOCAL CODE MAY REQUIRE DOUBLE CONTAINMENT TYPE HEAT EXCHANGER TO PREVENT CONTAMINATION.
 NOTE 3: EACH PWFY UNIT MAY CONNECT TO A DIFFERENT BC CONTROLLER / VRF SYSTEM FOR LARGER INSTALLS.

Figure 10. Domestic Hot Water Pre-Heat Sample Diagram

Radiant Floor / Snow Melt Supplemental Heating (HEX Unit)

The water temperatures capable of being generated by the HEX unit are within the range to supplement heating for in floor radiant heating and snow melt loops for a large range of climates and for a significant part of the heating season for many climates.

Application of the HEX unit in this scenario should be considered in conjunction with a main boiler system. In many cases the pick-up load for snow melt systems can be larger than actual snow melting load, so supplemental boiler heat may be especially necessary in many colder climates for this application to be effective.

When applying this product in conjunction with a primary boiler heat source, it is recommended to locate the HEX unit/s up-stream of the main boiler. In this way the HEX units can be loaded first or preferentially loaded during periods where the boiler is required to run when the HEX units are not capable of keeping up with the actual load.

It is also recommended to pump through the HEX units from the main heating loop using a side-stream pumping strategy. In this way, if the HEX units are not operable or in need or service, the main boiler system can continue to run, with water flow unaffected by the inoperable HEX unit/s.

As with other application of this product, this scenario could involve a single HEX unit or several HEX units from multiple VRF systems. The economics of this should be evaluated by the engineer / designer for each project.

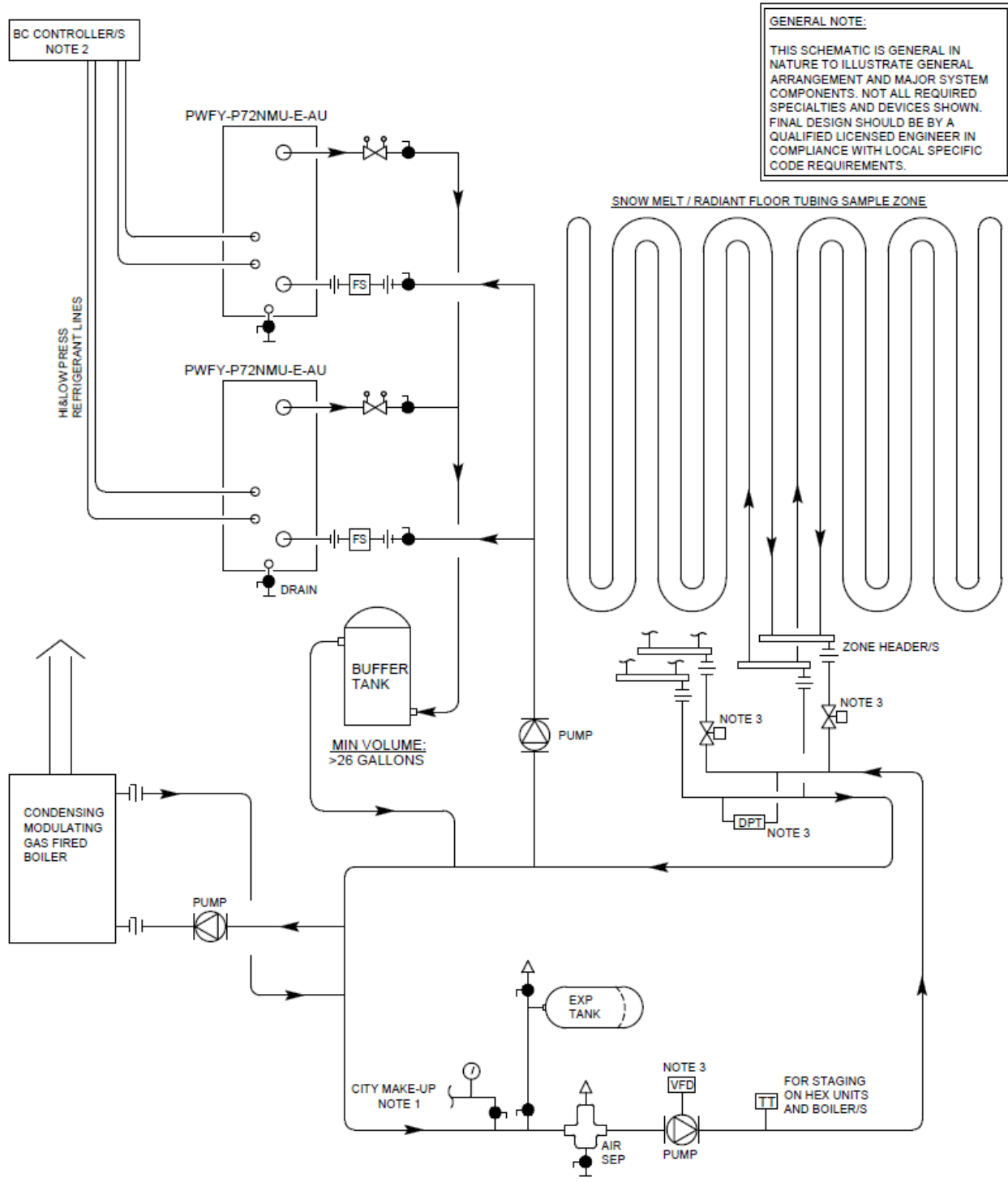
This application could be applied with other indoor fan coil units on an R2 system or a Y-series system. However, the largest benefit will come from a year round cooling dominate load profile among other fan coil units, where the absorbed heat in the system could be rejected to this type of heat sink.

If coupling the HEX unit to a VRF system with year round dominant cooling profile, it would be recommended to include the low ambient hood kit option on the outdoor equipment for air cooled applications. Since the units will be in cooling mode for the majority of the heating season, the low ambient kit will maintain higher temperature/pressure gas for use at the HEX units during these periods.

Figure 11A illustrates a potential application of this product for snow melt / in floor radiant heating applications with a backup boiler. In this application if snow melt loop temperatures below 80 degrees are required during long idle conditions, the backup boiler should be used to control such conditions. The HEX should be off during these snow melt idle periods, as sufficient heat and temperatures in HEX loop would not be present during idle periods to facilitate outdoor unit defrost. This will be more pronounced in 1to1 systems where only HEX units are connected to the outdoor unit.

Figure 11B illustrates snow melt considerations when no backup boiler is used (**not generally recommended**). This diagram depicts the need to cover outdoor unit defrost periods by maintaining a warmer water temperature through the HEX at all times. This could be accomplished with a buffer/mixing tank and a secondary pump loop with a mixing valve to allow for colder snow melt loop temps during idle periods.

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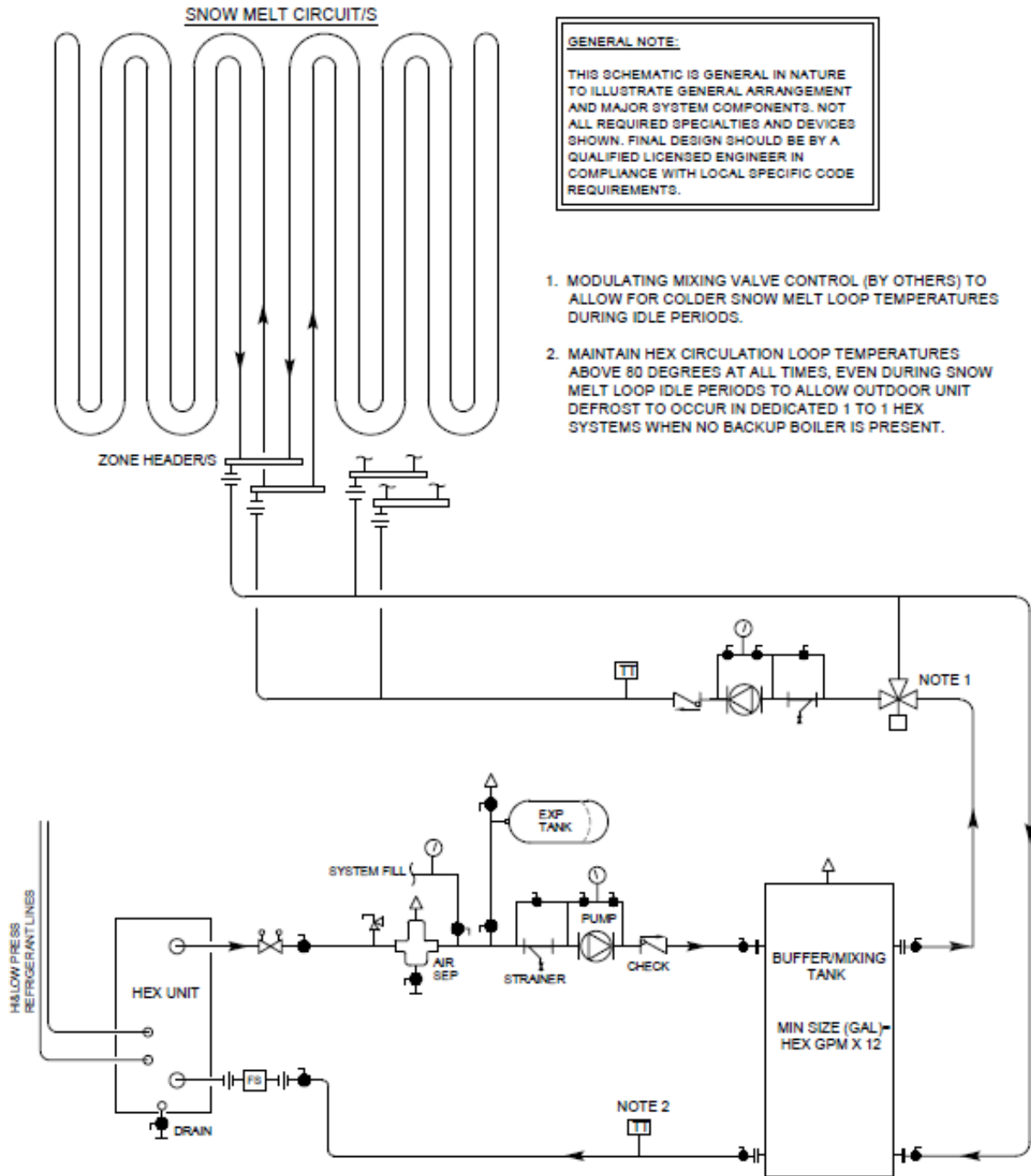


GENERAL NOTE:
 THIS SCHEMATIC IS GENERAL IN NATURE TO ILLUSTRATE GENERAL ARRANGEMENT AND MAJOR SYSTEM COMPONENTS. NOT ALL REQUIRED SPECIALTIES AND DEVICES SHOWN. FINAL DESIGN SHOULD BE BY A QUALIFIED LICENSED ENGINEER IN COMPLIANCE WITH LOCAL SPECIFIC CODE REQUIREMENTS.

- NOTE 1: RADIANT FLOOR: FROM CITY MAKE-UP WITH BACK-FLOW PREVENTION DEVICE PER LOCAL CODES.
 SNOW MELT: FROM GLYCOL FILL / MAKE-UP SYSTEM
- NOTE 2: EACH PWFY UNIT MAY CONNECT TO A DIFFERENT BC CONTROLLER / VRF SYSTEM FOR LARGER INSTALLS.
- NOTE 3: LARGER SYSTEMS MAY BENEFIT FROM INDIVIDUAL ZONE VALVE CONTROL AND VFD CONTROL OF MAIN CIRCULATION PUMP BASED ON LOOP REMOTE DIFFERENTIAL STATIC PRESSURE.

Figure 11A. Radiant Floor / Snow Melt Sample Diagram w/ Backup Boiler

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1. MODULATING MIXING VALVE CONTROL (BY OTHERS) TO ALLOW FOR COLDER SNOW MELT LOOP TEMPERATURES DURING IDLE PERIODS.
2. MAINTAIN HEX CIRCULATION LOOP TEMPERATURES ABOVE 80 DEGREES AT ALL TIMES, EVEN DURING SNOW MELT LOOP IDLE PERIODS TO ALLOW OUTDOOR UNIT DEFROST TO OCCUR IN DEDICATED 1 TO 1 HEX SYSTEMS WHEN NO BACKUP BOILER IS PRESENT.

Figure 11B. Snow Melt Sample Diagram When No Backup Boiler Is Present

Domestic Hot Water Booster Heating Applications (Booster Unit)

As mentioned previously the Booster unit is capable of producing hot water with temperatures up to 160 deg F. This is the ideal for serving potable process hot water needs such as commercial kitchen sanitizing / washing equipment.

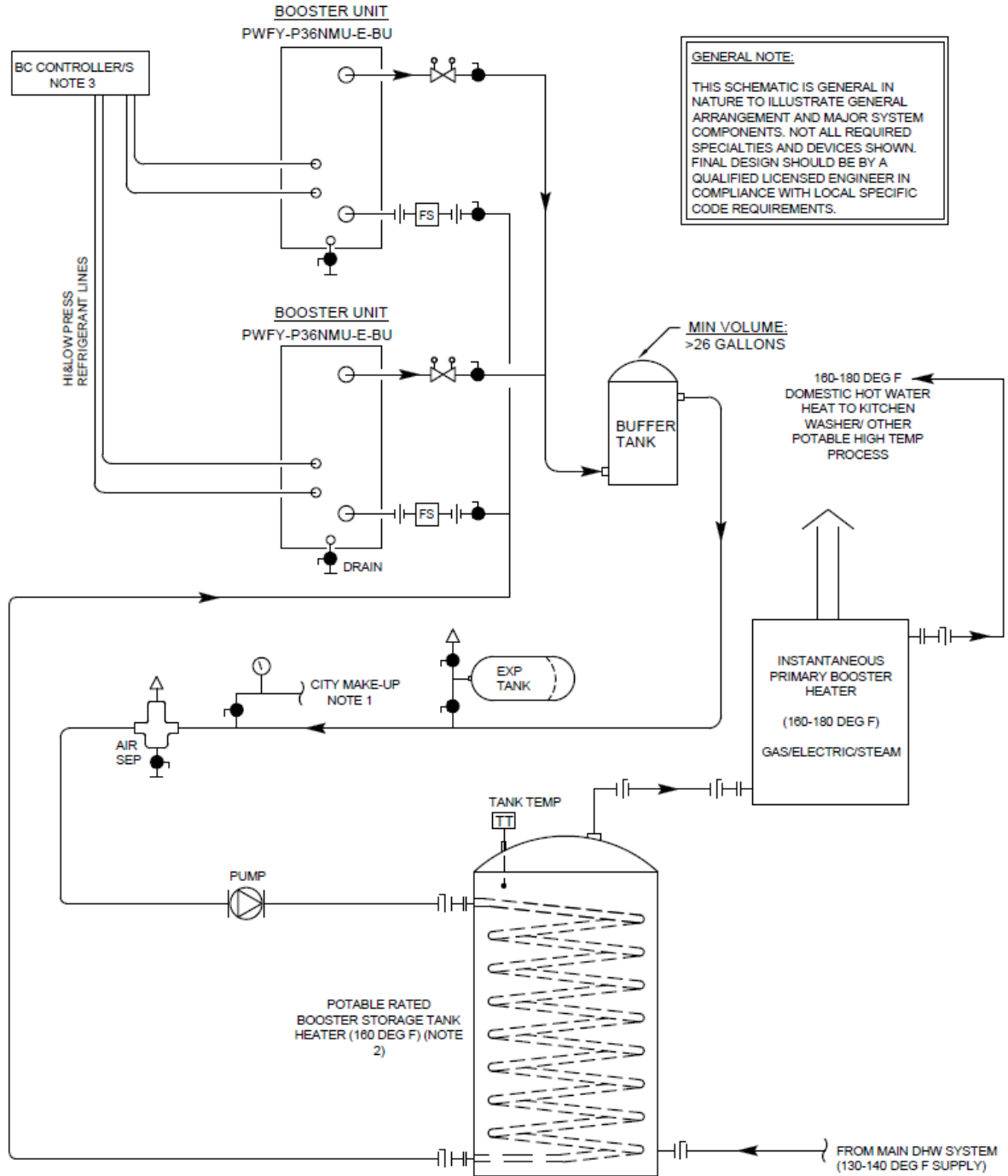
Process hot water requirements for sanitation purposes typically require, by code, heating of the water above 140 deg F to destroy *legionella* at all times. For this reason, the booster unit should be coupled with a secondary downstream conventional fuel source water heater that is available at all times to ensure process temperatures are achieved.

As with domestic hot water pre-heat applications using the HEX unit, consider using a booster pre-heat storage tank upstream of the conventional heater. Sizing this storage tank to cover peak use draw is important to maximize unloading potential of the downstream heater. If space permits a larger storage volume tank may be warranted.

This storage tank would then have a storage target temp of 160 deg F at all times. As system capacity is reduced due to ambient conditions, tank temperature may float, but in this way the booster is always maximizing output potential to hit the target storage temperature.

Figures 12 provide a suggestion for how this potential application could be applied. As always the designer / engineer of record should consult specific application requirements for end use equipment being served and comply with local code requirements.

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 NOTE 3: EACH PWFY UNIT MAY CONNECT TO A DIFFERENT BC CONTROLLER / VRF SYSTEM FOR LARGER INSTALLS.

Figure 12. Booster Unit – Domestic Hot Water Booster Application Sample Diagram

Using the HEX for Ventilation Air Handlers (DOAS)

Another potential application of the HEX product is for field constructed ventilation systems or dedicated outdoor air systems (DOAS) which are desired and are outside the range of our standard CFM & CFMR VRF units (covered by separate Applications Guide).

In colder climates especially, the need for supplemental auxiliary heat which is often in the form a separate downstream duct heater (electric or boiler hot water) may be required when applying the Mitsubishi VRF CFM/R DOAS product. Since the HEX units are connectable with the CITY MULTI Hyper Heat outdoor VRF units, extended heat pump range and heating capacity can be provided for a DOAS unit if coupled to a Hyper Heat product.

Any application in this regard will obviously require the use of a secondary water loop and a hydronic air handler (by others) for construction of the DOAS system. As always, the hydronic loop should be a closed loop system and will require glycol for freeze protection since it is a 100% outdoor air application.

The graphical schematic representation of this potential application is shown on the following page. One item to note in this schematic is suggestion of a buffer tank. Since this is a 100% outdoor air treatment application, disruption to space conditions and comfort could result if no back up heat source is provided during periods of defrost operation of the outdoor unit. The suggested buffer tank would provide some thermal storage to mitigate the effects of momentary performance loss during defrost operation.

In the application shown in Figure 13, the ventilation air from this system would be more suited for introduction into the return air opening or mixing section in duct of the indoor fan coils, due to the lack of a re-heat coil to provide room neutral conditioned air.

Another Potential application would be to utilize the HEX unit connected to an R2 system with other indoor fan coils.

In this scenario shown in Figure 14, the DOAS (field provided) could be coupled to the Lossnay product for heat recovery to minimize the need of auxiliary supplemental heat. This option provides improved efficiency with heat recovery potential via two heat sinks (building air and the refrigeration loop).

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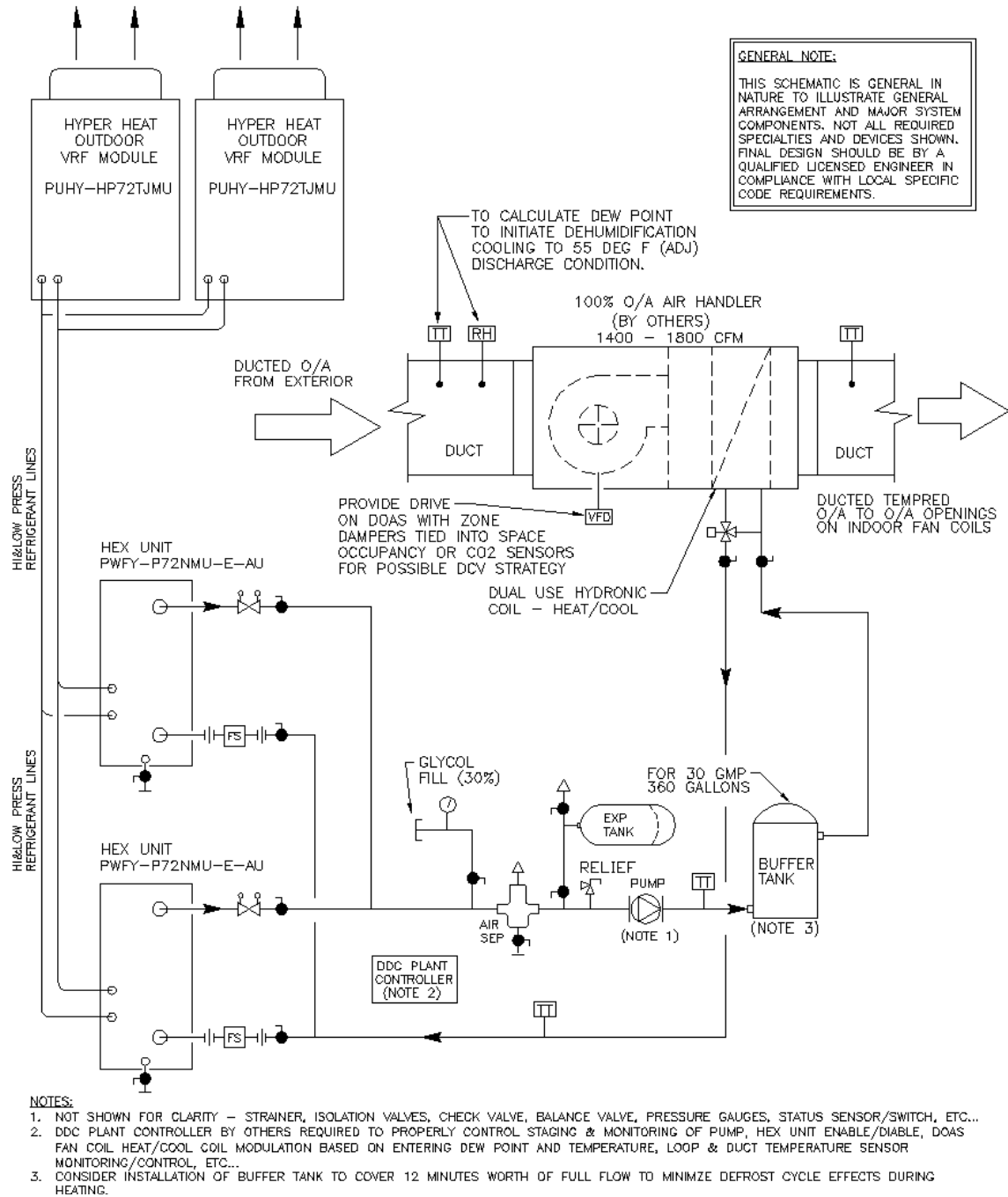
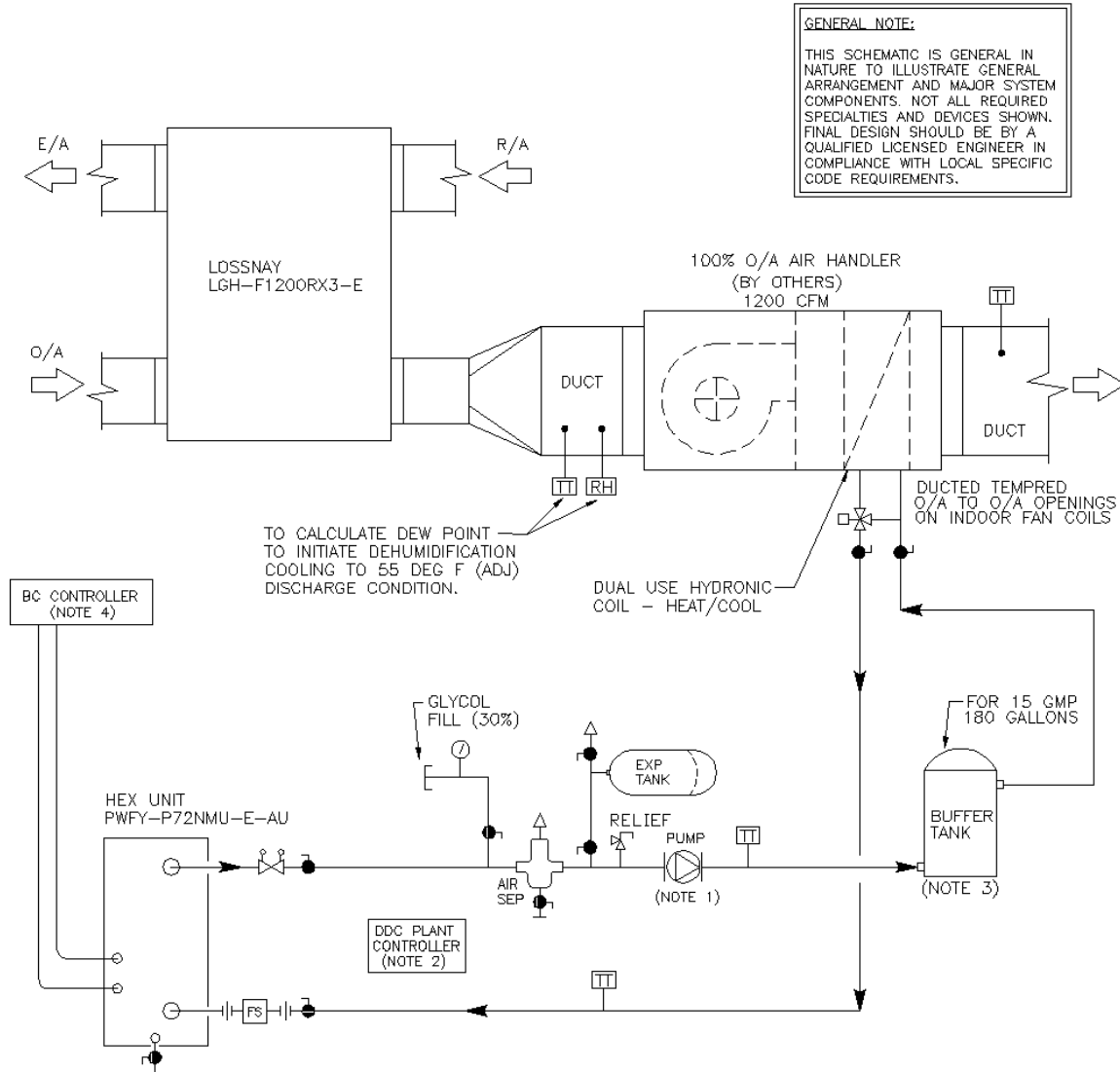


Figure 13. Using the Hex with Hyper Heat for DOAS Application



- NOTES:**
1. NOT SHOWN FOR CLARITY - STRAINER, ISOLATION VALVES, CHECK VALVE, BALANCE VALVE, PRESSURE GAUGES, STATUS SENSOR/SWITCH, ETC...
 2. DDC PLANT CONTROLLER BY OTHERS REQUIRED TO PROPERLY CONTROL STAGING & MONITORING OF PUMP, HEX UNIT ENABLE/DIABLE, DOAS FAN COIL HEAT/COOL COIL MODULATION BASED ON ENTERING DEW POINT AND TEMPERATURE, LOOP & DUCT TEMPERATURE SENSOR MONITORING/CONTROL, ETC...
 3. CONSIDER INSTALLATION OF BUFFER TANK TO COVER 12 MINUTES WORTH OF FULL FLOW TO MINIMIZE DEFROST CYCLE EFFECTS DURING HEATING.
 4. HEX UNIT SERVED BY CITY MULTI R2 SYSTEM - BC CONTROLLER SHOWN WOULD SERVE OTHER INDOOR FAN COILS (NOT SHOWN).

Figure 14. Using the HEX on R2 with Lossnay Product for DOAS