Providing insights for today's HVAC system designer

ENGINEERS NEWSLETTER

Volume 52-4 // November 2023

Hydronic Variable Refrigerant Flow HVAC Systems

Heating and cooling account for 30 percent of CO_2 emissions in commercial buildings. To decarbonize operations, building owners are moving away from the use of fossil fuels, such as gas-fired burners to heat their buildings, and turning to electrified HVAC equipment like heat pumps. Simultaneously, a transition to lower Global Warming Potential (GWP) refrigerants is underway. Many of these new refrigerants are slightly flammable which will present additional system design challenges.

This Engineers Newsletter will introduce an additional variation of VRF heat pump systems and their benefits in moving towards a decarbonized world.

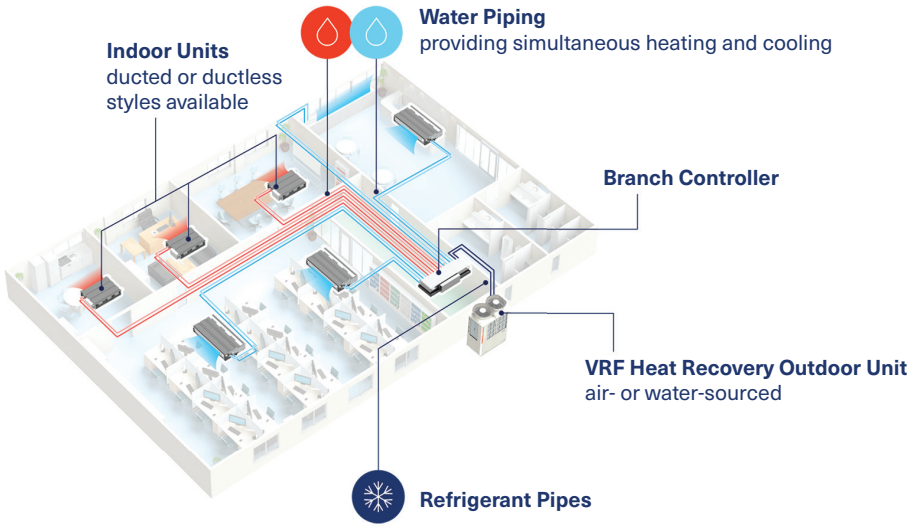
Introduction

Variable Refrigerant Flow (VRF) systems are a popular all-electric choice for many building types. These heat pump systems provide zoned comfort with features like heat recovery for simultaneous heating and cooling, and they offer a relatively simple design with built-in controls.

Hydronic variable refrigerant flow systems are the next generation of all-electric heat pumps and will help satisfy upcoming demands for reduced refrigerant charge (see Figure 1). A hydronic variable refrigerant flow system is a unique two-pipe hydronic VRF zoning system, using a combination of refrigerant and water to cool and heat simultaneously. These improvements allow two-pipe hydronic systems to provide the comfort of a conventional four-pipe chiller plus boiler system with the simplicity and efficiency of modern VRF air conditioning.

Hydronic variable refrigerant flow systems use less refrigerant overall, up to 30 percent on average when compared to conventional VRF solutions. As a result, hydronic variable refrigerant flow systems are a key technology in the movement to decarbonize buildings while simultaneously reducing the flammability concerns present with the transition to refrigerants with a lower GWP.

Figure 1. Hydronic variable refrigerant flow system



Hydronic Variable Refrigerant Flow Explained

A hydronic variable refrigerant flow system is a unique combination of a heat recovery VRF system with many of the benefits of a four-pipe, water-based fan coil system using only two pipes. It combines the advantages of both system types and delivers them together in a pre-engineered package with a complete control system.

The system starts with the same heat recovery outdoor units and controls as a conventional VRF system (see Figure 2). Refrigerant lines connect the outdoor units to a branch controller which is where the differences with conventional VRF begin. In lieu of directing refrigerant capable of heating or cooling to the various zones, the branch controller will direct hot or cold water. In turn, each terminal device will utilize a hydronic coil in lieu of a refrigerant coil. Indoor units can be controlled by individual remotes and/or through centralized controllers or a building management system.

A complete hydronic variable refrigerant flow system will consist of the following components:

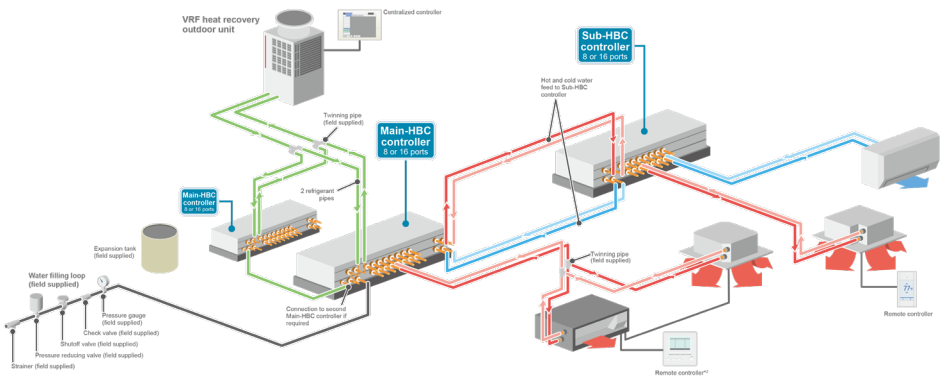
- Heat recovery outdoor units
- Main branch controllers
- Refrigerant-free sub-branch controllers for additional zones
- Hydronic terminal units
- Hydronic accessories/specialties
- System and unit-level controls

Hydronic variable refrigerant flow systems continue to offer a wide variety of indoor terminal unit options to fit any number of budling requirements:

- Ducted fan coils
- Ceiling cassettes
- Wall-mounted units

Applications for a hydronic variable refrigerant flow system include complex buildings that require individual temperature settings like hotels, offices, multifamily buildings, schools, and senior living facilities.

Figure 2. Hydronic variable refrigerant flow technical overview



Main Hybrid Branch Controller (HBC) - The Heart of a Hydronic Variable Refrigerant Flow System

At the heart of any hydronic variable refrigerant flow system lies the main Hybrid Branch Controller known as the “HBC” as shown in Figure 3. Like a branch controller in a VRF system, this component includes any valves necessary to direct heat to or from the various zones. But unlike a conventional branch controller, the HBC includes both refrigerant-to-water heat exchangers and variable-speed pumps for both the cold and hot water distribution headers.

A sub-HBC, Figure 4, is also available to increase the number of zones that can be served. Unlike the main HBC, however, a sub-HBC does not contain any refrigerant. This means that the sub-HBC can be located anywhere in an occupied space.

Figure 3. Main branch controller (HBC)

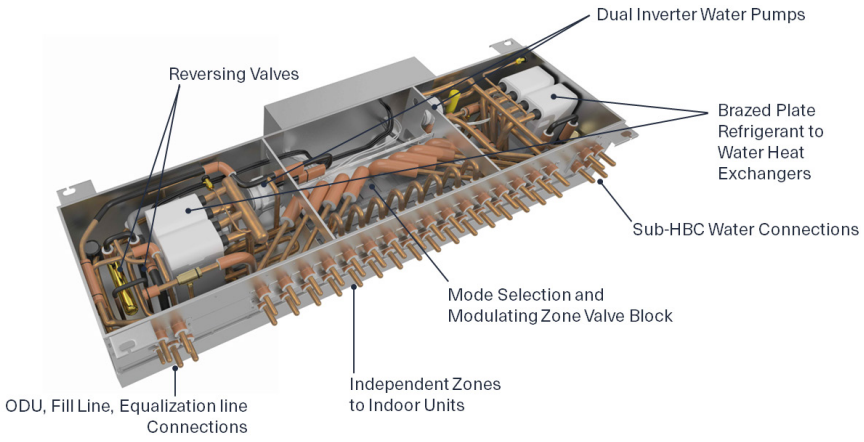
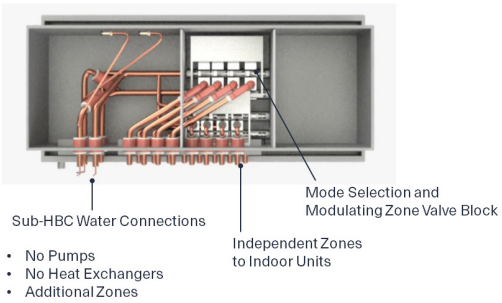


Figure 4. Sub-branch controller (Sub-HBC)



Hydronic Variable Refrigerant Flow vs Conventional VRF

Like a VRF system, benefits such as heat recovery for simultaneous heating and cooling and zoned comfort are still enabled with a hydronic variable refrigerant flow system. Likewise, hydronic variable refrigerant flow systems continue the legacy of a simple design with built-in controls to optimize efficiency.

The conversion to water requires extra components which can have an impact on overall system efficiency. However, these impacts may be offset by several benefits. A hydronic variable refrigerant flow system provides the following additional benefits compared to a conventional VRF system:

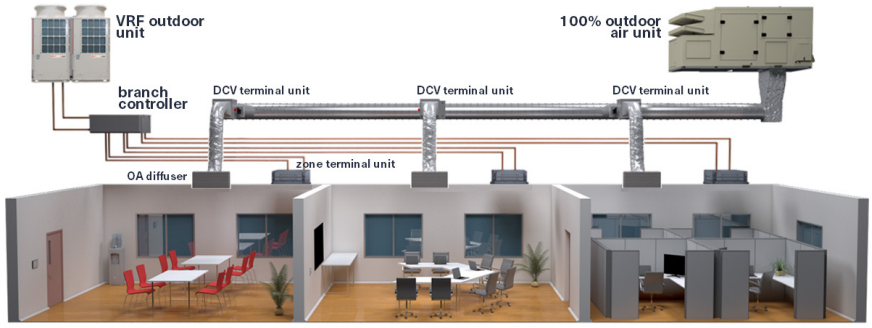
- No refrigerant lines in occupied spaces
- Less refrigerant charge overall, 30 percent less on average
- Tighter temperature control
- Reduced defrost penalty
- Easier to install (less copper piping)
- Less noise, especially during defrost

Like a conventional VRF system, a complete hydronic variable refrigerant flow system will pair the terminal distribution system with a properly designed ventilation system, see Figure 5.

Refrigerant Safety

Recent updates to refrigerant safety standards, like ANSI/ASHRAE® Standard 15 *Safety Standard for Refrigeration Systems*, have added new requirements for when flammable refrigerants are used in many HVAC systems. These requirements can be difficult to comply with in some buildings, especially those with small spaces. In addition, for a building classified as an "institutional" occupancy (that is, one where the building occupants can't leave without assistance or of their own free will), the limit on refrigerant charge is even more stringent.

Figure 5. Complete VRF or Hydronic Variable Refrigerant Flow System



By using refrigerant for the piping between the outdoor unit and the HBC, and water for the piping to the terminal units, a hydronic variable refrigerant flow system will use less refrigerant overall, making compliance with the latest safety standards easier. Elimination of refrigerant in the occupied spaces may also result in fewer leak detection systems required.

Application Considerations

Although there are many details to consider when designing a hydronic variable refrigerant flow system, a few are of particular importance to an HVAC system designer: ventilation design and considerations involving the use of hydronic piping.

Ventilation design

Like a conventional VRF system, a complete hydronic variable refrigerant flow system will pair the terminal distribution system with a properly designed ventilation system (see Figure 6).

In lieu of designing a ventilation system to provide a predetermined supply air temperature, a psychrometric analysis to ensure proper space humidity is recommended. For the ventilation system, a Dedicated Outdoor Air System (DOAS) will likely be the ideal choice to ensure proper ventilation and control of space humidity.

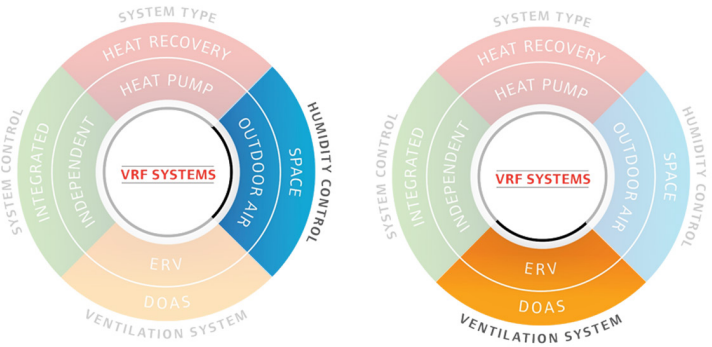
Hydronic piping

A hydronic variable refrigerant flow system is a complete, pre-engineered system from the outdoor unit to the terminal equipment. With integral pumps and valves, the hydronic piping system is applied more like the refrigerant lines in a conventional VRF system than a conventional hydronic system. For example, limits on both line length and component elevation differences will be provided by the system manufacturer.

The type of piping is also important. Multi-Layer Pipe (MLP) is the piping of choice to meet the pressure drop and efficiency requirements of a hydronic variable refrigerant flow system, see Figure 7 below. This is a composite multi-layer pipe consisting of PERT-AL-PERT construction: where PERT refers to polyethylene raised temperature and AL refers to the aluminum material. MLP comes pre-insulated in rolls or sticks, depending on pipe diameter, for reduced insulation cost.

Figure 7. Multi-layer piping (MLP)

Figure 6. VRF system design



Humidity Control
Will the ventilation air be conditioned to a predetermined supply air temperature or to ensure adequate space humidity?

Ventilation System
Will the ventilation air be conditioned by an energy recovery ventilator (ERV) or a DOAS?

The importance of a hydronic variable refrigerant flow system in the United States

The U.S. has ratified both the American Innovation and Manufacturing (AIM) Act and the Kigali Amendment which will make A2L refrigerants (a class of non-toxic, lower flammability refrigerants) mandatory for many types of HVAC equipment, including heat pump systems, beginning January 1, 2026. To meet new global warming potential (GWP) regulations, the industry will change from using traditional high-pressure refrigerants in VRF systems, like R410A, to A2L classified refrigerants with lower GWP.

More than 20 states have established mandatory decarbonization goals and more than 45 states have utility incentives for electrified equipment in residential and/or commercial buildings. Likewise, 141 U.S. cities have committed to 100 percent clean, renewable energy. It's easy to understand why: replacing fossil fuel-based HVAC systems with all-electric systems could, by sme estimates, reduce energy usage by more than 40 percent and carbon emissions by at least 75 percent!

Decarbonization involves reducing the carbon dioxide equivalent footprint of buildings. Electrification is one of the primary methods of decarbonizing a building by removing fossil-fuel dependency from HVAC systems. Heat pump technology, like that found in VRF and hydronic variable refrigerant flow systems, is a proven way to electrify a building. But decarbonization goes beyond just electrification, a reduction in refrigerant charge and the use of low-GWP refrigerants furthers the decarbonization goal.

A hydronic variable refrigerant flow system continues to offer the electrification benefits of VRF and can result in a substantial reduction in the carbon footprint of a building.

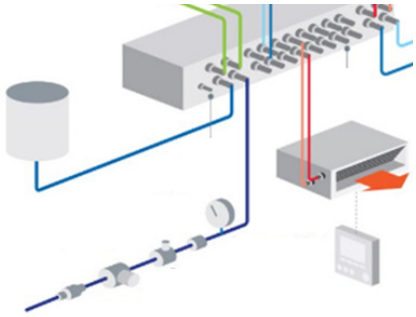
Hydronic design and water specialties

The use of water between the HBC and the terminal units will necessitate several water specialties (Figure 8) to address the following:

- Water fill
- Water expansion
- Water quality and treatment
- Water air and debris removal

Like a conventional VRF system, these specialties will be pre-engineered. A complete component list with required sizing should be provided by the hydronic variable refrigerant flow system manufacturer.

Figure 8. Water specialties



Summary

Hydronic variable refrigerant flow systems as shown in Figure 2, are the next generation of all-electric heat pumps and will help satisfy upcoming demands for decreased refrigerant usage. It combines the simplicity of a standard VRF system with the benefits of water and will provide the system designer with another option to help reduce greenhouse gas emissions.

By Dustin Meredith, Trane. To subscribe or view previous issues of the Engineers Newsletter visit trane.com. Send comments to ENL@trane.com.

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Contact your local Trane office for more information or visit www.Trane.com/ENL.

For more information on Hydronic Variable Refrigerant Flow Systems, please visit: **www. trane.com/hvrf**

Additional VRF Resources:

- Variable Refrigerant Flow Systems catalog (APP-PRC007*-EN)
- *Engineers Newsletter Live* programs
  "Applying VRF for a Complete Building Solution" Parts I and II.
  Visit the Trane Education Center to view and earn PDH credit.

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ADM-APN089-EN
November 2023