Variable Refrigerant Flow (VRF)

What is VRF?

Variable Refrigerant Flow (VRF) is a type of direct expansion (DX) heating and cooling system that operates by modulating the flow of refrigerant in response to equipment load conditions.

Indoor VRF units:
https://www.ahi-carrier.com/en/product/indoor-vrf-units/

What are the advantages of VRF?

The primary advantage of VRF is a higher level of energy efficiency during certain common system conditions. Unlike traditional DX split systems which cycle on and off, VRF systems can operate continuously at part-load with a higher overall efficiency. For the majority of the year HVAC systems do not need to operate at full-load, so any system that can be designed for maximum part-load efficiency has an advantage over a system designed primarily for full-load efficiency. Some VRF systems are available with heat recovery, rejecting the heat generated from space cooling to another space in the system that requires heating. Heat recovery offers very high overall efficiency in situations that require simultaneous heating and cooling.

VRF systems also offer additional advantages typically associated with a four-pipe fan coil system without the additional hydronic equipment. VRF terminals in different spaces are zoned separately and can provide simultaneous heating and cooling to different spaces while being served by the same condenser. There is no compressor noise in the space, resulting in very low system noise. Additionally, the absence of an internal compressor in the room unit means that there are fewer system components that would require maintenance in the occupied space.

VRF systems allow much longer refrigerant piping lengths than traditional split systems, and may be more easily applied to retrofit projects than ducted systems. VRF systems are modular, with moderately sized outdoor condensing units. This makes the coordination and placement of outdoor HVAC equipment easier than hydronic systems which often require much larger chillers or cooling towers.

VRF Condensers:
https://www.therma.com/the-benefits-of-vrf-vrv-systems

What are the disadvantages of VRF?

The most readily apparent disadvantage of a VRF system is a much higher initial cost than traditional split systems and many hydronic systems, like water source heat pumps (WSHP).

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The Washington State University Energy Program identified a premium of 20-50% over a baseline code compliant system. It should be noted that installed system cost data is scarce and the available data is highly variable.

VRF systems have much higher refrigerant volumes than comparable DX or hydronic systems. The larger refrigerant volumes required by VRF lead to an increased likelihood of a system design being in violation of ASHRAE 15 requirements[1]. In order to comply, a larger system may need to be divided into multiple smaller systems; the result of which is reduced opportunities for simultaneous heating and cooling.

Unlike hydronic equipment, all VRF equipment is manufacturer specific, meaning that VRF system owners are required to use the same manufacturer for all components throughout the system's lifespan. Manufacturers also use varying piping schemes, with mixtures of two-pipe and three-pipe refrigerant runs.

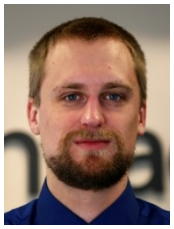
Because it is wholly refrigerant based, VRF is much more likely to become outmoded through legislation affecting allowable refrigerant types.

While VRF systems can provide longer refrigerant line lengths than typical DX split systems, they are not able to achieve the line lengths that can be achieved with hydronic systems. The long line lengths in a VRF system reduces the overall efficiency because pumping refrigerant is significantly less efficient than pumping water.

Summary:

Variable refrigerant flow systems are one of the most efficient HVAC systems available, however they are not without operational limitations and are not a good fit for every project. The highest cost of a VRF system remains a major drawback to its use. VRF systems are a viable option in many instances, particularly when high efficiency, modularity, and physical space considerations are of utmost importance.

About Seth:



Seth Nelsen, P.E., has been involved in the design, and drafting of mechanical systems for malls, mixed-use developments, corporate offices, national retail roll-outs, commercial and institutional buildings for over 6 years with Schnackel Engineers.

Seth has a Masters in Architectural Engineering from the University of Nebraska at Omaha and is a Licensed Professional Engineer in the State of California.

RESOURCES	
HVAC system design requires methodical assessment of the options:	http://unitedstates.xylemappliedwater.com/files/2018/11/CBS-White-Paper-11_6_18.pdf
Utility Program Cost Effectiveness of Variable Refrigerant Flor Systems:	https://aceee.org/files/proceedings/2016/data/papers/3_345.pdf
Heat Pumps: Variable Refrigerant Flow (VRF) vs. Conventional:	http://e3tnw.org/ItemDetail.aspx?id=200
Modern Hydronics vs. Variable Refrigerant Flow Systems	http://mesteksa.com/fileuploads/Literature/SpacePak/SpacePak/WWNL-12-15%20number%203.pdf
Variable Refrigerant Flow Systems	https://www.gsa.gov/cdnstatic/GPG_Variable_Refrigerant_Flow_12-2012.pdf
Hydronic vs. VRF - which, when and why?	https://www.pmmag.com/articles/100840-hydronic-vs-vrf---which-when-and-why

[1] ASHRAE 15 governs the maximum volume of refrigerant allowed in any system based on the volume of the smallest room connected to that system.