HVAC - Multi-Split Variable Refrigerant Flow (VRF)

An Online Continuing Education Course for Engineers

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HVAC – Multi-Split Variable Refrigerant Flow (VRF) Systems

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VRF (variable refrigerant flow) is an air-conditioning system configuration that has one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow (VRF) refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides individualized comfort control and simultaneous heating and cooling in different zones.

Widely applied in large buildings, especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries in Japan, who named and protected the term variable refrigerant volume (VRV) system so that other manufacturers must use the term “variable refrigerant flow” (VRF). In essence, both are the same.

With higher efficiency and increased controllability, the VRF system can help achieve a sustainable design. Unfortunately, the design of VRF systems is more complicated and requires additional work compared to designing a conventional direct expansion (DX) system.

This course provides an overview of VRF system technology.

OVERVIEW OF VRF SYSTEMS

The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There is a wide range of air conditioning systems available, starting from the basic window-fitted unit to the small split systems, medium scale package units, large chilled water systems, and the latest variable refrigerant flow (VRF) system.

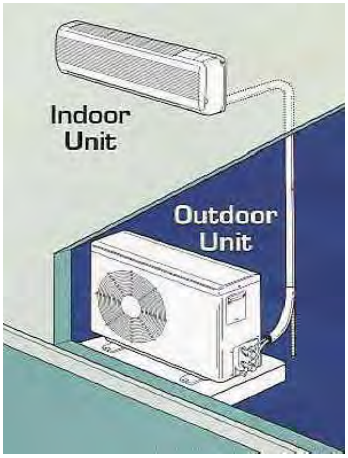
The term VRF refers to the ability of the system to control the amount of refrigerant flowing to each of the evaporators, enabling the use of many evaporators of differing capacities and configurations, individualized comfort control, simultaneous heating and cooling in different zones, and heat recovery from one zone to another. VRF systems operate on the direct expansion (DX) principle, meaning that heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space. Refrigerant flow control is both the key to many advantages and the major technical challenge of VRF systems.

Note that the term VRF systems should not be confused with the centralized VAV (variable air volume) systems, which work by varying the airflow to the conditioned space on variation in room loads.

Split Air-Conditioning Systems

Split type air conditioning systems are one to one systems consisting of one evaporator (fan coil) unit connected to an external condensing unit. Both the indoor and outdoor units are connected through copper tubing and electrical cabling.

The indoor part (evaporator) pulls heat out from the surrounding air, while the outdoor condensing unit transfers the heat into the environment.



Split Air-conditioning System

Advantages of using Split Air conditioners

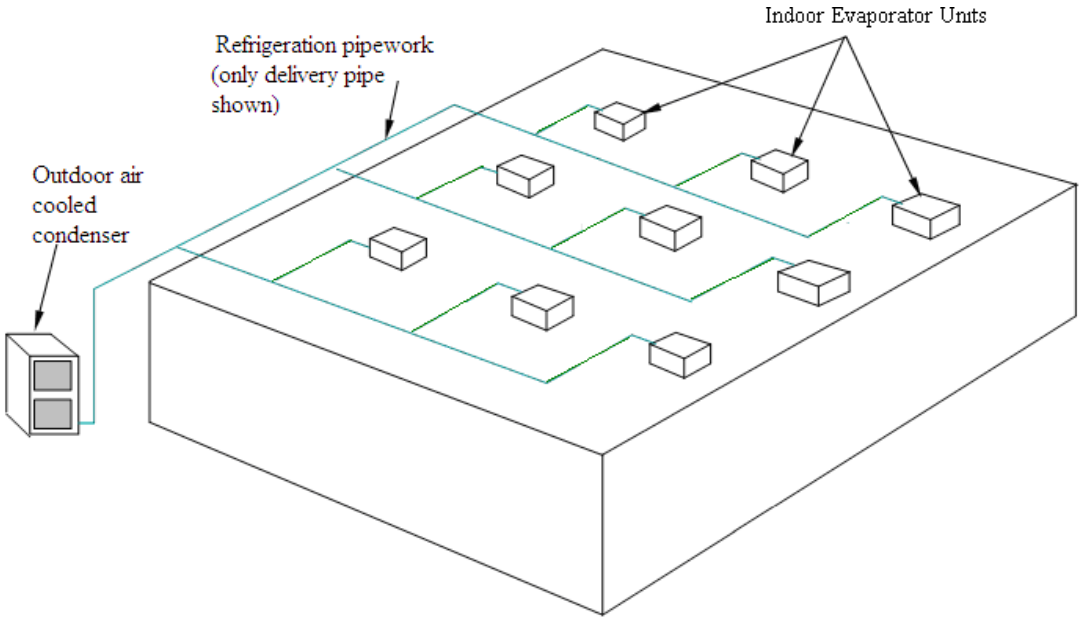
- Low initial cost, less noise, and ease of installation
- A good alternative to ducted systems
- Each system is totally independent and has its own control

Disadvantages

- There is a limitation on the distance between the indoor and outdoor unit; i.e., refrigerant piping cannot exceed the limits stipulated by the manufacturer (usually 100 to 150 feet); otherwise, the performance will suffer
- Maintenance (cleaning/change of filters) is within the occupied space
- Limited air throw, which can lead to possible hot/cold spots
- Negative impact on building aesthetics of large buildings, because too many outdoor units will spoil the appearance of the building

Multi-Split Systems

A multi-type air conditioning system operates on the same principles as a split type air conditioning system; however, in this case, there are *multiple* evaporator units connected to one external condensing unit. These simple systems were designed mainly for small to medium commercial applications where the installation of ductwork was either too expensive or aesthetically unacceptable. The small-bore refrigerant piping, which connects the indoor and outdoor units, requires much lower space and is easier to install than the metal ducting. Each indoor unit has its own set of refrigerant pipework connecting it to the outdoor unit.



Typical Multi-Split System

Advantages of Multi-splits

- The fact that one large condenser can be connected to multiple evaporators within the building reduces and/or eliminate the need for ductwork installation completely.
- Multi-splits are suitable for single thermal zone* applications with very similar heat gains/losses.

Drawbacks

- Inability to provide individual control
- Multi-split systems turn OFF or ON completely in response to a single thermostat/control station, which operates the whole system. These systems are, therefore, not suitable for areas/rooms with variable heat gain/loss characteristics.

*Thermal zone: A thermal zone is referred to as a space or group of spaces within a building with similar heating and cooling requirements. Each thermal zone must be 'separately controlled' if conditions conducive to comfort are to be provided by an HVAC system.

Any area that requires different temperatures, humidity, and filtration shall be categorized as an independent zone, and shall be controlled by dedicated control or HVAC system. The following examples illustrate and clarify the zone concept:

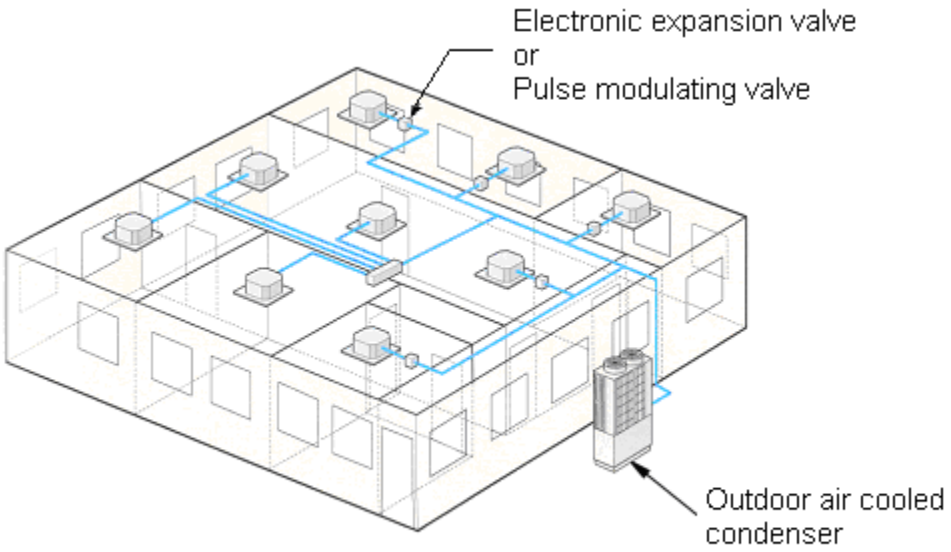
- A conference room designed for 50-person occupancy shall experience lower temperatures when it is half or quarterly occupied. The design thus shall keep provisions for a dedicated temperature controller for this zone
- A smoking lounge of an airport has different filtration, ventilation (air changes) and pressure requirements compared to other areas; therefore, it is a separate zone
- A hotel lobby area is different from the guest rooms or the restaurant area because of occupancy variations
- In a commercial building, the space containing data processing equipment such as servers, photocopiers, fax machines, and printers see much larger heat load than the other areas, and hence is a different thermal zone
- A hospital testing laboratory, isolation rooms and operation theatre demand different indoor conditions/pressure relationships than the rest of areas and thus shall be treated as separate zones
- A control room or processing facility in an industrial set up may require a high degree of cleanliness/positive pressure to prevent the ingress of dust/hazardous elements, and thus may be treated as a separate zone

Variable Refrigerant Flow or VRF Systems

VRF systems are similar to the multi-split systems, which connect one outdoor section to several evaporators. However, multi-split systems turn OFF or ON completely in response to one master controller, whereas VRF systems continually adjust the flow of refrigerant to each indoor evaporator. The control is achieved by continually varying the flow of refrigerant through a pulse modulating valve (PMV), whose opening is determined by the microprocessor receiving information from the thermistor sensors in each indoor unit. The indoor units are linked by a

control wire to the outdoor unit, which responds to the demand from the indoor units by varying its compressor speed to match the total cooling and/or heating requirements.

VRF systems promise a more energy-efficient strategy (estimates range from 11% to 17% less energy compared to conventional units) at a somewhat higher cost.



VRF System with Multiple Indoor Evaporator Units

The modern VRF technology uses an inverter-driven scroll compressor, and permits as many as 48 or more indoor units to operate off one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in total cooling/heating load as determined by the suction gas pressure measured on the condensing unit. The capacity control range can be as low as 6% to 100%.

Refrigerant piping runs of more than 200 feet are possible, and outdoor units are available in sizes up to 240,000 Btuh.

A schematic VRF arrangement is shown below:

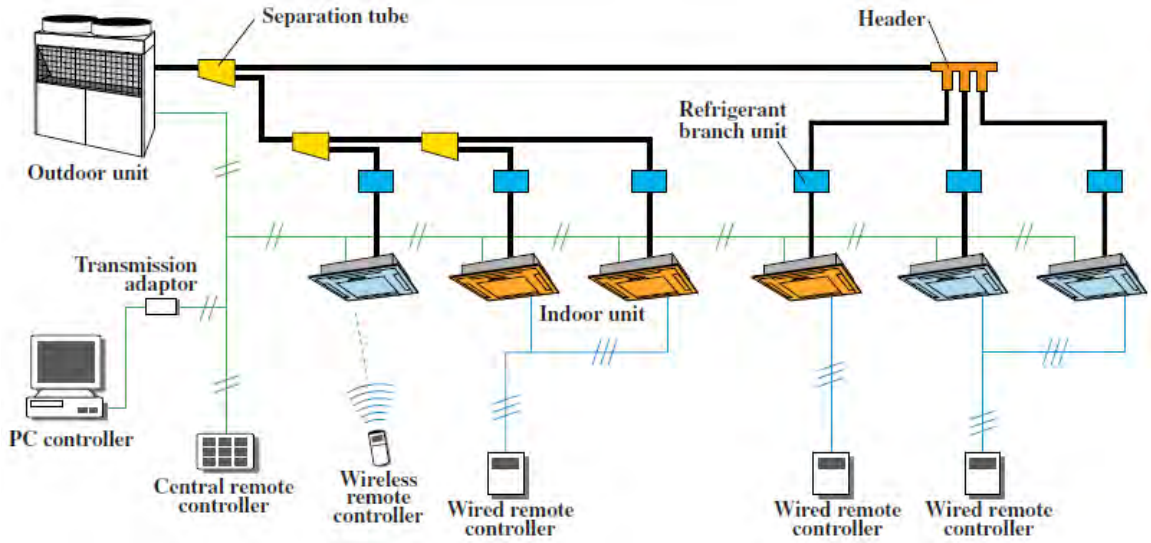


Figure (Source: Fujitsu)

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipework uses a number of separation tubes and/or headers (refer to the schematic figure above).

The separation tube has two branches, [illegible] than two branches. Either or both the separation tub[illegible]e separation tube is **NEVER** provided after the [illegible]