

Variable Refrigerant Flow in Air Conditioning of Buildings: System Configuration and Energy Efficiency

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Abstract Variable Refrigerant Flow (VRF), also known as Variable Refrigerant Volume (VRV) refers to the ability of an air-conditioning (AC) system to control the amount of refrigerant flowing to multiple evaporators (indoor unit). This study evaluates the VRF system to its core, and how the system is more beneficial in terms of built environment than the traditional air-conditioning system. This type of system consists of a number of air handling units (possibly up to 48) connected to a modular external condensing unit. The refrigerant flow in the VRF system is varied using either an inverter-controlled variable speed compressor or multiple compressors of varying capacity in response to changes in the cooling or heating requirement within the air-conditioned space. With the help of these advanced compressor like the twin rotary compressor the metering device can be closed to controls the flow of refrigerant between the indoor and outdoor unit which helps in avoiding the overheating or overcooling of the space. VRF system also helps in covering the duct losses which is impossible to cover in traditional system as VRF system is ductless or minimum duct are used in the process.

Keywords: air conditioning, buildings, variable refrigerant flow, energy efficiency, compressor

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1. Introduction

VRF systems which are also known as VRV 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 [3]. 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 [1].

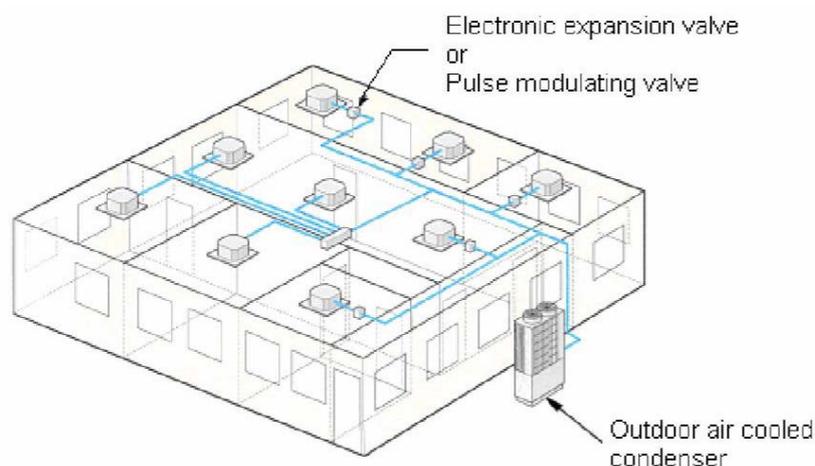


Figure 1. VRF system with Multiple Indoor units [1]

2. Research Methodology

In this paper qualitative research method has been used. The systematic literature review has been explored through internet and secondary data from relevant published academic literature from journals articles and research papers. The data collection in the qualitative research are the data that comes from a number of case study examples that are described descriptively and are supported by illustrations and photographs to reinforce the arguments put forward. The basic concepts and backgrounds are investigated through literature and on-line media, observations to work for qualitative analysis conducted for Variable Refrigerant Flow in Air Conditioning of Buildings with reference to system operation and energy efficiency.

3. Principles of VRF/VRV

- Refrigerant only where refrigerant is the only coolant material in the system (in contrary to the chilled water systems, where refrigerants is used for cooling/heating the water that is circulated throughout the whole system).
- Inverter compressors that allow lowering power consumption with partial cooling/heating loads.
- Several air handlers (indoor units) on the same refrigerant loop/circuit.
- Ability of modular expansion (especially applicable for large projects that can grow in stages)

4. VRF System Structure

- A typical system consists of an outdoor unit (comprising one or multiple compressors), several indoor units, refrigerants piping, running from the outdoor to all indoors, using refried joints (copper distributes in pipes) and communication wiring.

- Communication wire consists of a 2 wired cable, chained from the outdoor to all indoors, creating an internal closed loop network that is an essential part of any VRV/VRF installation.
- Maximum connection of 64 indoor unit to 1 outdoor unit.

5. Overview of VRF System

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

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 the key to many advantages as well as the major technical challenge of VRF systems.

6. Components of VRF System

The modern VRF technology uses an inverter-driven scroll compressor and permits as many as 48 or more indoor units to operate from one outdoor unit (varies from manufacturer to manufacturer). The inverter scroll compressors are capable of changing the speed to follow the variations in the 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%.

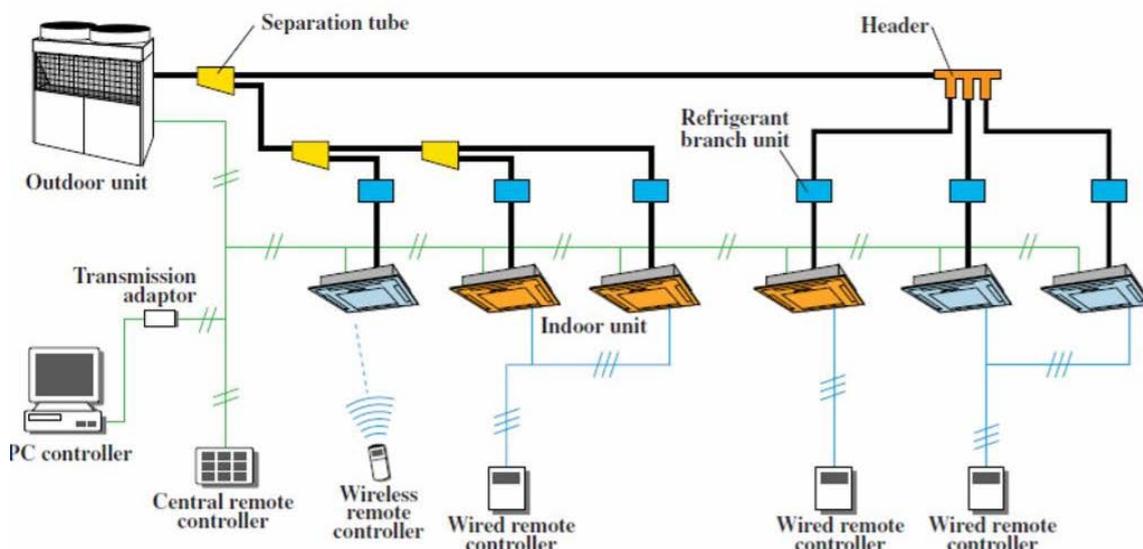


Figure 2. A Schematic VRF Arrangement Figure [1]

6.1. Digital Scroll Compressor

The scroll compressor works in two phases one is to pump and second is to compress or pressurize fluids. Modern VRF system uses the digital scroll compressor operates in two stages in the working environment one is the loaded stage when the valve in the compressor is normally closed and the other stage is unloaded when it is open. During the loaded state, compressor act as normal compressor and delivers full capacity and refrigerant flow. However, during the unloaded state, there is no capacity and refrigerant flow discharged through the compressor.

6.2. Inverter Scroll Compressor

The main difference between the inverter and the digital scroll compressor is that the inverter scroll compressor continuously regulates the temperature, keeping it at the desired temperature. The inverter compressor eliminates all the start at stop that is done by the traditional on reaching the desired temperature which makes it more it more efficient in terms of energy. Inverter compressor have precision temperature control and have high efficiency as it delivers only the energy needed to satisfy the cooling or heating conditions. Not only that they have great control over humidity as well.

6.3. Twin Rotary Compressor

The twin rotary compressor has an advantage over the typical scroll compressor as it requires less oil to pump from the compressor to the refrigerant system. By reducing the amount of oil that is required it helps in efficiency. Most of the oil that is circulated by the twin rotary compressor can be further isolated to the system's outdoor unit. As because of the further isolation the metering device can be closed completely as the zone is satisfied with the isolation which is not possible in scroll compressor. Because of closing of metering device refrigerant will be unable to circulate through the unit and avoids overcooling or overheating of the space. The result is greater as well as higher efficiency.

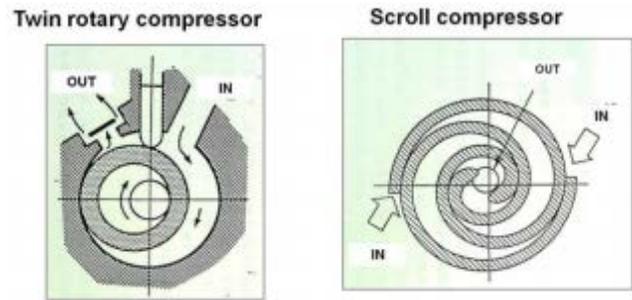


Figure 3. Comparing Rotary and Scroll Compressor [14]

6.4. Comparison of VRF System on the Basis of Compressor

There are generally three types of compressor that changes the functioning of the VRF system as compressor is one of the main components that maintains the flow of refrigerant and helps in maintaining the cooling and heating environment. The three units are summarized as follows:

6.4.1. Single Variable Speed Compressor

In this system with a single, large-capacity scroll compressor, the same compressor starts and runs when there is demand and no redundancy is available if the compressor fails. [14].

6.4.2. Variable Speed compressor Plus Fixed-Speed Compressor

In this two-compressor system, the inverter driven compressor always starts and ramps up until it reaches its maximum capacity, at this time the fixed-speed compressor starts and inverter-driven compressor ramps down. This system provides back-up capability [14].

6.4.3. Multiple Variable Speed Compressor

Multiple inverter-driven compressors allow the unit to provide better part load performance without the need to use hot gas bypass. Under low-load conditions, the system has the advantage of running only as many compressors at whatever speed is required to achieve the capacity necessary to satisfy the load and maintain comfort within the conditioned space.

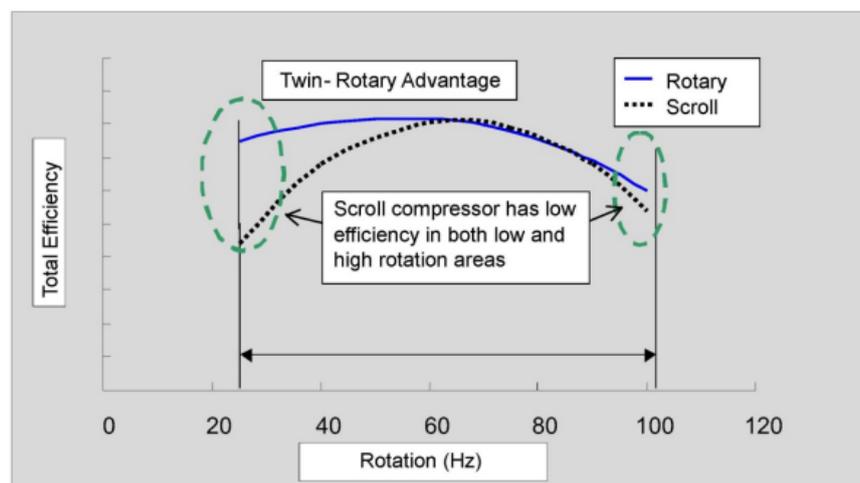


Figure 4. Compressor Efficiency [14]

6.5. Separation Tube and Header

Separation tube and header are connection parts of the system and are the important design features. VRF system are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipe-work uses a number of separation tubes or and/or header. A separation tube consists of 2 branches whereas header has more than 2. Either of the separation tube or header, or both can be used for branches. However, the separation tube is never provided after the header because of the balancing issues [1].

7. Engineering System

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches. However, the separation tube is NEVER provided after the header because of balancing issues. Compared to multi-split systems, VRF systems minimize the refrigerant path and use less copper tubing. VRF systems are engineered systems and use complex refrigerant and oil control circuitry. A separation tube has 2 branches whereas a header has more than 2 branches.

Either of the separation tube or header, or both, can be used for branches. However, the separation tube is never provided after the header because of balancing issues. Compared to multi-split systems, VRF systems minimize the refrigerant path and use less copper tubing. The minimizing the refrigerant path allows for maximizing the efficiency of refrigerant work.

Variable refrigerant flow (VRF) is an air-condition system configuration where there is one outdoor condensing unit and multiple indoor units. The term variable refrigerant flow 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 an individualized comfort control, and simultaneous heating and cooling in different zones.

Bases on inverter technology compressors the VRF technology/system was developed and designed by Daikin Industries, Japan in 1982, Daikin has registered the VRV term, which stands for variable refrigerant volume as an official trademark. So other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

With a 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.

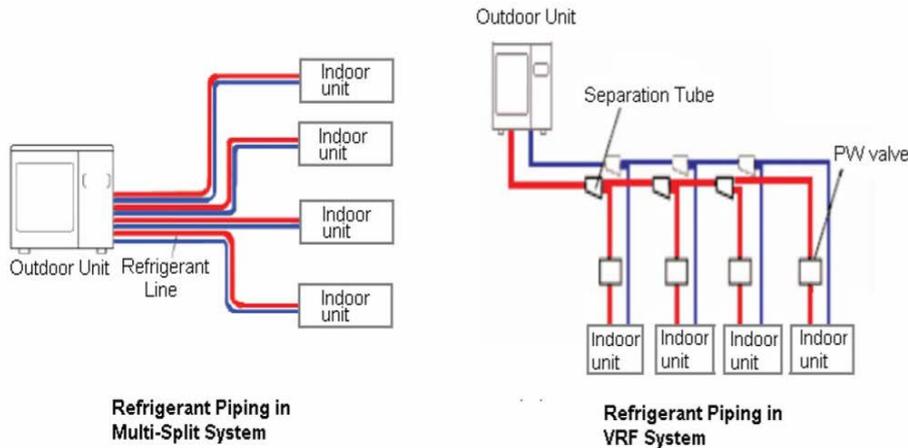


Figure 5. Refrigerant Piping System in Multi- Split System and VRF System [1]

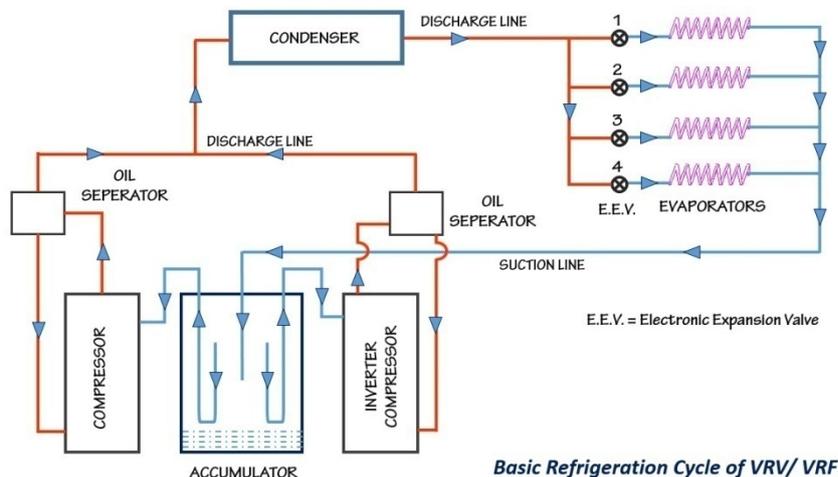


Figure 6. Basic Refrigeration cycle of VRV/VRF

7.1. Basic Refrigeration Cycle of a VRV/VRF System

7.1.1. Suction Accumulator

The primary function of the suction accumulator is to catch and hold any liquid refrigerant that didn't boil off in the evaporator. Liquid refrigerant getting to the compressor can damage the pistons or scrolls. This liquid will also dilute or even flush the oil out of the compressor crank case. This loss of oil will prevent proper lubrication to the compressor, causing compressor damage or failure. Inside the accumulator is a U-shaped tube that will allow only the refrigerant vapor to exit and enter the compressor.

7.1.2. Working of Inverter Compressor

An inverter compressor is a gas compressor that is operated with an inverter. This type of compressor uses a drive to control the compressor motor speed to modulate cooling capacity. Capacity modulation is a way to match cooling capacity to cooling demand to application requirements. The Inverter technology (DC) is the latest evolution of technology concerning the electro motors of the compressors. An Inverter is used to control the speed of the compressor motor, so as to continuously regulate the temperature. The DC inverter units have a variable-frequency drive that comprises an adjustable electrical inverter to control the speed of the electromotor, which means the compressor and the cooling / heating output. The drive converts the incoming AC current to DC and then through a modulation in an electrical inverter produces current of desired frequency. A microcontroller can sample each ambient air temperature and adjust accordingly the speed of the compressor. The inverter air conditioning units have increased efficiency in contraction to traditional air conditioners.

7.1.3. Variable Frequency Drive

A Variable Frequency Drive (VFD) is a type of motor controller that drives an electric motor by varying the frequency and voltage supplied to the electric motor.

Other names for a VFD are variable speed drive, adjustable speed drive, adjustable frequency drive, AC drive, micro drive and inverter.

7.1.4. Oil Separator

Oil separators are used on refrigeration systems where it's difficult for the oil to return from the evaporator. Oil separators are installed in the compressor/ compressors discharge line. They're usually a vertical container with the discharge gas connections at the top and an oil return port at the bottom. This return line may be piped directly to the suction line on single compressor units or on multiple compressor racks would be piped to a holding tank called an oil reservoir. Some oil separators have a reservoir built into the bottom portion of the container with the upper portion being the separator. From the reservoir, the oil is then returned to the compressors by use of a mechanical or electronic oil level control fastened to the compressor crankcase.

Sometimes during compression, the lubrication oil of compressor goes out with refrigerant and the piping length of VRV/VRF system is very large so the return of oil to compressor is very difficult, thus, we use oil separators outside compressors, which separate oil from refrigerant and give it back to compressors.

7.1.5. Electronic Expansion Valve (EEV)

Electronic expansion valve is used in Inverter air conditioning system to adjust flow of refrigerant automatically. Thus the air conditioner can always stay at the optimized working conditions with quick cooling, precise temperature control, low energy consumption, etc. This valve can also be used for other controls. This valve is reversible and can control the flow under either cooling or heating condition. The electronic expansion valve (EEV) operates with a much more sophisticated design. EEVs control the flow of refrigerant entering a direct expansion evaporator. They do this in response to signals sent to them by an electronic controller. A small motor is used to open and close the valve port.

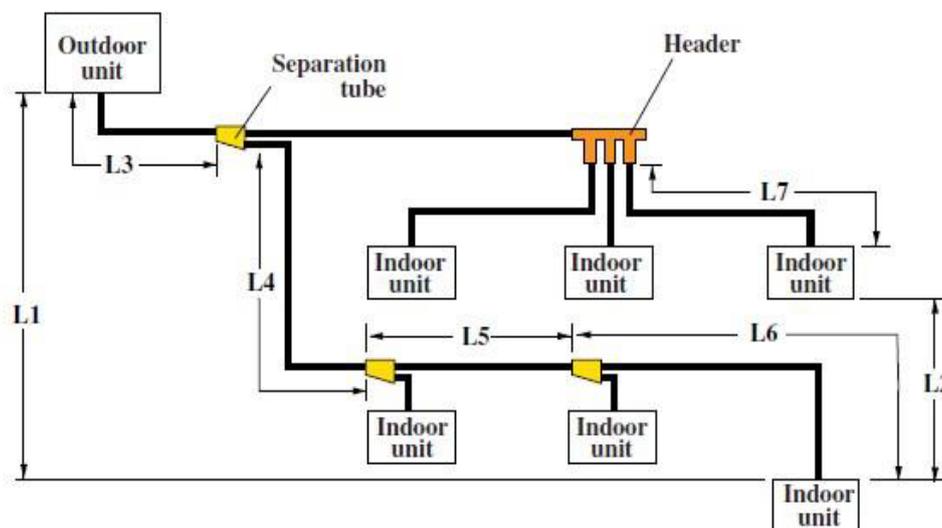


Figure 7. Length of Refrigerant Pipes

However, the cost of electronic valves, which includes the sensors, regulator, actuator and the valve itself, is still much higher than for the simple and mechanical thermal expansion valve. Electronic expansion valves are therefore mostly found on very large systems and systems with a high demand for precise regulation. Evaporators are equipped with thermostat sensors which regularly monitor the load on evaporator. The thermostat sensor sends the signal to microprocessor controller located in outdoor unit through a communication cable, about the load of an evaporator, signal then goes to VFD and VFD adjusts the frequency going to inverter compressor and inverter compressor works accordingly.

Each indoor unit uses an expansion valve to control its refrigerant supply to match the cooling/heating demand of the space it serves.

7.1.6. Length of Refrigerant Pipes

L1: Maximum height difference between outdoor unit and indoor unit = 50m

L2: Maximum height difference between indoor unit and indoor unit = 15m

L3: Maximum piping length from outdoor unit to first separation tube = 70m

[L3+L4+L5+L6]: Maximum piping length from outdoor unit to last indoor unit = 100m

L6 & L7: Maximum piping length from header to indoor unit = 40m

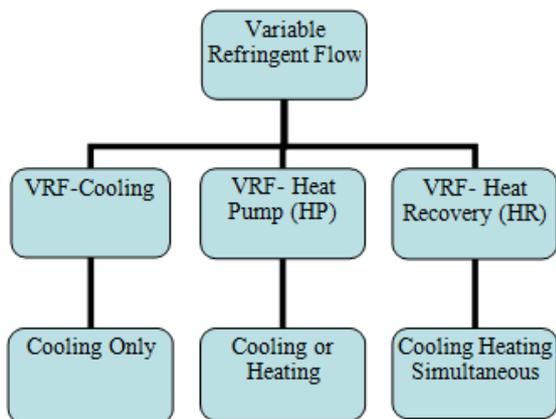
Total piping length = 200m (Liquid pipe length)

If pipes with a diameter larger than 3/4 in. (19.05 mm) are specified, use semi-hard (C1220T- 1/2H) or hard (C1220T-H) copper piping. If a softer copper pipe (C1220T-O) is used. [1]

8. Types of VRF Systems

VRF systems can be used only for cooling. On heat pump models there are two basic types of VRF system. VRF system basically follows three types of cycle, cooling cycle, heating cycle, and cooling and heating cycle. The basis of working of VRF system in different conditions is these three cycles and further with the help of these three cycles the whole system is designed. With the help of these three it is possible for the VRF system to heat and cool at the same time. The basic three types of VRF system are as follows:

Table 1. Different types of VRF Systems



8.1. Cooling Type VRF

This type of VRF system is capable to provide only cooling to a thermal zone. It doesn't provide heating.

- Compressor converts the low pressure, low temperature vapor refrigerant into high pressure, high temperature vapor refrigerant and after compression the refrigerant goes into condenser coil.
- Heat rejection takes place at condenser coil as the vapor refrigerant into it is at very high temperature in comparison to atmospheric temperature, after rejecting heat, refrigerant cools down and condenses to liquid form.
- Condensed liquid refrigerant rejects only latent heat in condenser coil that means it is not cooled down completely, its temperature is high even after condensation. Refrigerant completely cools down only after passing through expansion valve.
- After condensation the high pressure, high temperature liquid refrigerant goes in discharge line. Separation tube diverts the common flow of refrigerant to an individual evaporator, the flow of refrigerant is further metered by an EEV (Electronic Expansion Valve), according to the thermal load on evaporator.
- More the load on the evaporator, more the refrigerant will pass through the respective Electronic Expansion Valve (EEV). The refrigerant completely cools down and pressure is also dropped.
- When low pressure, low temperature liquid refrigerant goes into evaporator coil it extracts heat from the thermal zone. After extracting heat, the liquid refrigerant starts boiling and converts into vapor form.
- The low pressure, low temperature vapor refrigerant from all evaporators then enters the main suction line and goes back to compressor and the cycle continues.

8.2. VRF – Heat Pump (HP)

The VRF heat pump systems permit heating or cooling in all the indoor units, but not simultaneously heating and cooling. When the indoor units are in the cooling mode, they act as evaporators; when they are in the heating mode, they act as condensers. These are also known as two-pipe systems. This system is equipped with Non-Return Valves (NRV) s and heat pump reversing valve. The heat pump reversing valve is the only difference between the heat pump and standard air conditioner.

8.2.1. NRV- Non-Return Valve

A non-return valve, check valve, clack valve, or one-way valve is a valve that normally allows fluid (liquid or gas) to flow through it in only one direction. They are connected with EEV in parallel connection.

8.2.2. Heat Pump Reversing Valve / 4 Way Reversing Valve

The heat pump reversing valve allows us to move the heat from inside the house to the outdoors (cooling mode) or to reverse the cycle and remove the heat from outside

the house to the indoors (heating mode). A heat pump reversing valve is an electro-mechanical 4-way valve that

reverses the refrigerant (Freon) flow direction, using an electrical magnet.

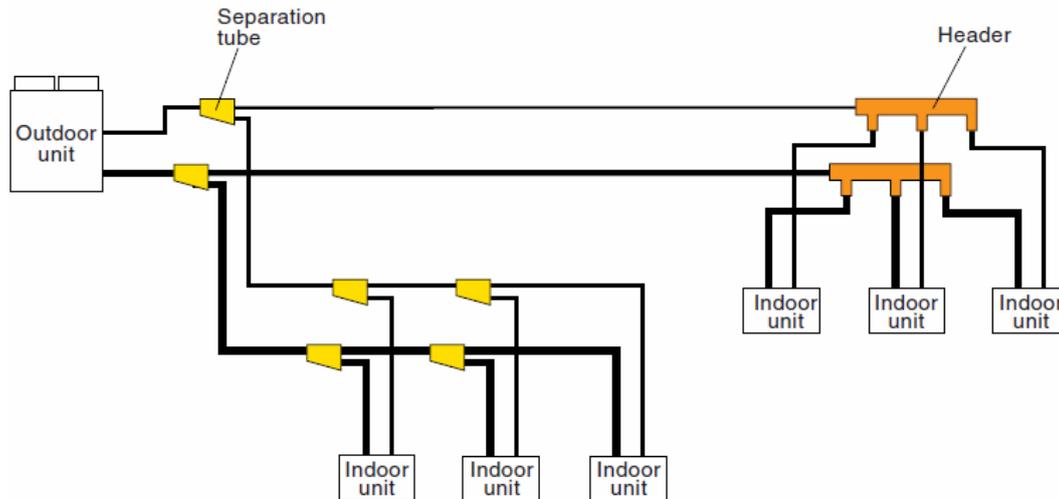


Figure 8. A Typical Heat Pump System

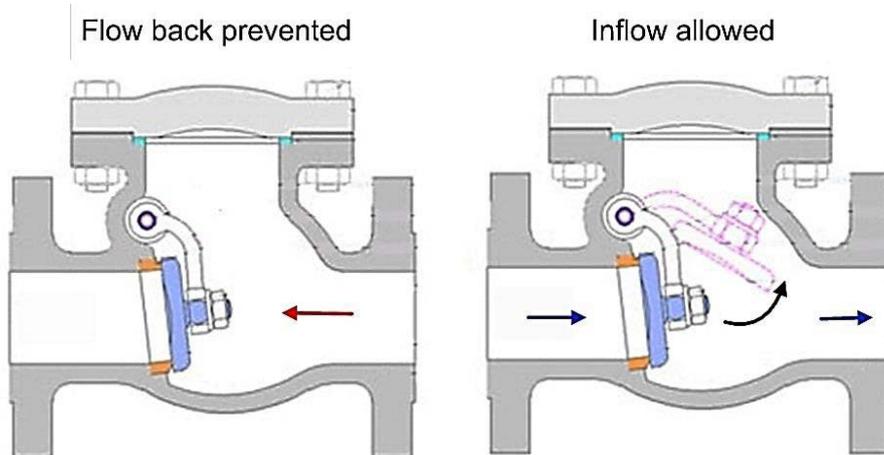


Figure 9. Flow with NRV

8.2.3. Heat Pump – Heating Cycle

- In heating cycle, C1 and C2 valves are closed. Now High Pressure, High Temperature vapor refrigerant coming from compressor passes through H1 valve and goes into indoor coils. Here it loses its heat as the thermal zone has comparably low temperature. After rejecting heat inside thermal zone, refrigerant condenses and converts its state from vapor to liquid. After condensation it passes through NRV, bypassing EEV.
- When HP, HT (High Pressure, High Temperature) liquid refrigerant enters outdoor unit, it cannot pass through NRV, as its direction is opposite to the direction of flow of the refrigerant, therefore refrigerant has to pass through EEV of outdoor unit. After passing through EEV the pressure and temperature of the liquid refrigerant drops drastically.
- Now LT, LP (Low Pressure, Low Temperature) liquid refrigerant enters outdoor unit coil where it absorbs heat from outside and boils up. (i.e., vaporize)
- Now LP, LT refrigerant in vaporized state will pass through H2 valve and finally goes back to

compressor and the cycle continues to provide heating.

8.3. VRF – Heat Recovery (HR)

Variable refrigerant flow systems with heat recovery (VRF-HR) capability can operate simultaneously in heating and/or cooling mode, enabling heat to be used rather than rejected as it would be in traditional heat pump systems. VRF-HR systems are equipped with enhanced features like inverter drives, pulse modulating electronic expansion valves and distributed controls that allow system to operate in net heating or net cooling mode, as demanded by the space.

Each manufacturer has its own proprietary design (2-pipe or 3-pipe system), but most uses a three-pipe system (liquid line, a hot gas line and a suction line) and special valve arrangements. Each indoor unit is branched off from the 3 pipes using solenoid valves. An indoor unit requiring cooling will open its liquid line and suction line valves and act as an evaporator. An indoor unit requiring heating will open its hot gas and liquid line valves and will act as a condenser. Typically, extra heat exchangers in distribution boxes are used to transfer some reject heat

from the superheated refrigerant exiting the zone being cooled to the refrigerant that is going to the zone to be heated. This balancing act has the potential to produce significant energy savings. VRF-HR mixed mode operation leads to energy savings as both ends of the thermodynamic cycle are delivering useful heat exchange. If a system has a cooling COP (Coefficient of Performance) of 3, and a heating COP of 4, then heat recovery operation could yield a COP as high as 7 [10]. It should be noted that this perfect balance of heating and cooling demand is unlikely to occur for many hours each year, but whenever mixed mode is used energy is saved. Units are now available to deliver the heat removed from space cooling into hot water for space heating, domestic hot water or leisure applications, so that mixed mode is utilized for more of the year.

VRF-HR systems work best when there is a need for some of the spaces to be cooled and some of them to be heated during the same period. This often occurs in the winter in medium-sized to large sized buildings with a substantial core or in the areas on the north and south sides of a building. There are 3 cycles in Heat Recovery (VRF-HR).

- Cooling and heating cycle.
- Only cooling cycle.
- Only heating cycle.

8.3.1. Cooling and Heating Cycle

In this cycle, reversing valve has 2 valves, Valve – 1 will be open and Valve – 2 will be closed. Compressor compresses the LT, LP (Low Pressure, Low Temperature) vapor refrigerant and converts it into high pressure and high temperature vapor refrigerant. Now high pressure and high temperature vapor refrigerant enters Valve – 1 of reversing valve, and then enters heat exchanger of outdoor unit, at the same time it also goes in hot gas line/discharge line. At heat exchanger, refrigerant condenses as outside temperature is comparatively low. Now liquid refrigerant will pass through NRV, bypassing EEV and goes to liquid line. Now there is high pressure and high temperature vapor refrigerant in hot gas line and high pressure and high temperature liquid refrigerant in liquid line.

9. VRF and Energy Efficiency

Although, there are many factors that decides the efficiency of a VRF system the most common is the inverted driven compressor system which allows the VRF system more precise control of the necessary refrigerant circulation amount required according to the system load because of linear step control. of the necessary refrigerant circulation amount required according to the system load [1]. Inverter technology provides efficient energy performance and also with the help of smooth capacity control comfortable environment can be achieved easily as compared to traditional rotary or reciprocating type compressor. Not only that VRF system minimizes the ductwork as there is one outdoor unit which is not only cost efficient but also covers the duct losses. Some other factors that make the VRF system more energy efficient are given as below:

9.1. Building Load Profile

The load profile for the building is sized based on the peak load of all the indoor sections at any given time. Adding up the peak load for each indoor unit and using that total number to size the outdoor unit likely will result in an unnecessarily oversized outdoor section. Although an oversized outdoor unit in a VRF system is capable of operating at lower capacity, avoid oversizing unless it is required for a particular project due to an anticipated future expansion or other criteria.

9.2. Sustainability

One attractive feature of the VRF system is its higher efficiency in comparison to conventional heat pump units. Less power is consumed by the VRF system at part load compared to conventional systems, which is due to the variable speed driven compressors and fans at outdoor sections [15].

9.3. Fresh Air Requirements

One of the most challenging aspects of designing VRF systems is the need to provide a separate outside air supply to each unit to comply with ANSI/ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality, and building codes. A separate outside air fan and control system is generally required for larger buildings. In humid climates, providing preconditioned outside air to each indoor unit ensures good indoor air quality.

9.4. Simultaneous Heating and Cooling

Some manufacturers offer a VRF system capable of providing simultaneous heating and cooling. In those systems, although several indoor sections are connected to one outdoor section, some indoor sections can provide heating, while others provide cooling.

9.5. Minimum Outdoor Air Temperature

Using VRF heat pump units for heating and cooling can increase building energy efficiency, especially when the heating obtained from the heat pump mode replaces an electric resistance heating coil. Most VRF units provide higher heating capacities than conventional DX heat pumps at low ambient temperatures.

9.6. Power and Accessibility

Power and accessibility are required for all system components, including evaporators, outdoor condenser, branch selector, and condensate drain pumps (where applicable) [15].

9.7. Unit Selection and System Layout

The complete specification of a VRF system requires careful planning. Each indoor section is selected based on the greater of the heating or cooling loads in the area it serves. In cold climates where the VRF system is used as the primary source for heating, some of the indoor

sections will need to be sized based on heating requirements. When indoor sections are greatly oversized, the modulation function of the expansion valve is reduced or entirely lost.

10. Features and Benefits of VRF

- A VRF system is similar to a chiller but circulates refrigerant to each zone instead of water.
- A VRF heat pump system has performance and design attributes similar to a 2-pipe chiller.
- A VRF heat recovery system has performance and design attributes similar to a 4-pipe chiller system.
- Scalable project opportunities with modular design.
- Broad coverage of most vertical markets and climates.
- Individual zone control for Advanced zoning capabilities.
- Can operate up to 64 indoor fan coil units.
- Auto charging function.
- Continuous heating during defrost operation.
- Flexible piping limitations to meet a variety of building needs.
- Excellent energy efficiency, especially at part load conditions (IEER).
- Tie in to open protocol Building Automation systems through Lon Works® and BACnet® gateways [2].

11. Key Points for VRV Selection

Before selection of any VRV system, a minimum amount of information is required for accurate equipment selection and to apply an optimized design.

11.1. Indoor Units

Table 2. Selection of Indoor Unit

Peak Cooling Loads	Peak Heating Loads	Design Air Conditions
<ul style="list-style-type: none"> •Engineers will usually provide both Total & Sensible loads which should be entered •However, it is possible to select equipment using only Total or Sensible load 	Required when either Heating is the dominant operation or the heating design condition is below 0°C	<ul style="list-style-type: none"> •Also known as “air-on” or “mixed air” conditions •Nominal conditions are typically 26°C db & 19°C wb but rarely reflect actual conditions •Design air-on can also be given as db./RH% (e.g., 24°C & 50% RH)

11.2. Outdoor Units

Table 3. Selection of Outdoor Unit

Ambient Conditions	Pipe Length
<ul style="list-style-type: none"> • Both engineers and D&B contractors should have this information • If this information is not at hand, then use ASHRAE standard design conditions for the location 	<ul style="list-style-type: none"> • This is the linear length from one point to another NOT the total amount of piping • Both engineers and D&B contractors should be able to pin point the outdoor unit location • Be sure to also establish whether there is any vertical height between outdoor & indoor units

11.3. VRV System Selection - Avoid the Common Pitfalls

Table 4. Common Pitfalls of VRV

Common Mistake	Best Practice
Thinking VRV is just a “big” multi split DX system	VRV is a chiller circulating refrigerant instead of water
It’s a Zoning system thus an Indoor unit in EVERY room	Design VRV systems using same approach as VAV or WSHP
VRV is a “Ductless System”	More than 55% of units used are Ducted types!
Upgrade Indoor Units to the next capacity size	Use accurate load calculated values and trust selection software
Optimum selection of Controls is not important	Be knowledgeable on controls capabilities – minimize BAS or even elimination of BAS is often possible
The entire application needs to be VRV	Use VRV where it makes sense for the customer & project

12. Limitations of VRF System

VRF systems are not suitable for all applications. Some limitations include:

- There is a limitation on the indoor coil maximum and minimum entering dry- and wet-bulb temperatures, which makes the units unsuitable for 100% outside air applications especially in hot and humid climates.
- The cooling capacity available to an indoor section is reduced at lower outdoor temperatures. This limits the use of the system in cold climates to serve rooms that require year-round cooling, such as telecom rooms.
- The external static pressure available for ducted indoor sections is limited. For ducted indoor sections, the permissible ductwork lengths and fittings must be kept to a minimum. Ducted indoor sections should be placed near the zones they serve.

13. Conclusion

VRF system offers controls that match the space heating/ cooling loads requirements. VRF system is a more load and performance efficient solution to the problem of heating and cooling. VRF offers many of the features of the chilled water system, while maintaining the simplicity of DX type of central air conditioning system. With the introduction of modern compressor in the VRF system, VRF system is able to maintain the temperature in the indoor space without overheating and overcooling and also the fans in the outdoor units modulate their speed, saving energy at part load conditions. What also matters in the VRF system is the system selection according to the need of the built space and conditions of the surrounding as the technology is based on the vapor compression cycle. System capabilities and limitations should be evaluated carefully to determine the suitability of the VRF for a project and to enhance the design. However, there are some limitations as the system is still developing and have a long way to go. In comparison with the traditional system VRF system requires less space, solution of all the duct problems, more energy efficient, provides required heating and cooling temperature.

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