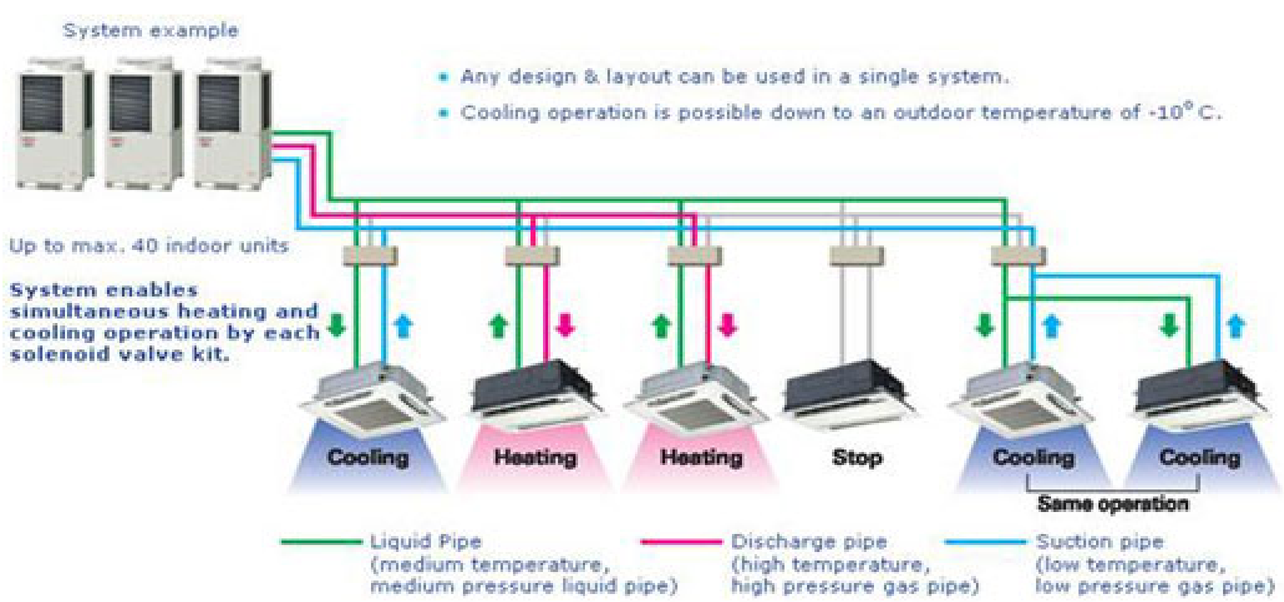
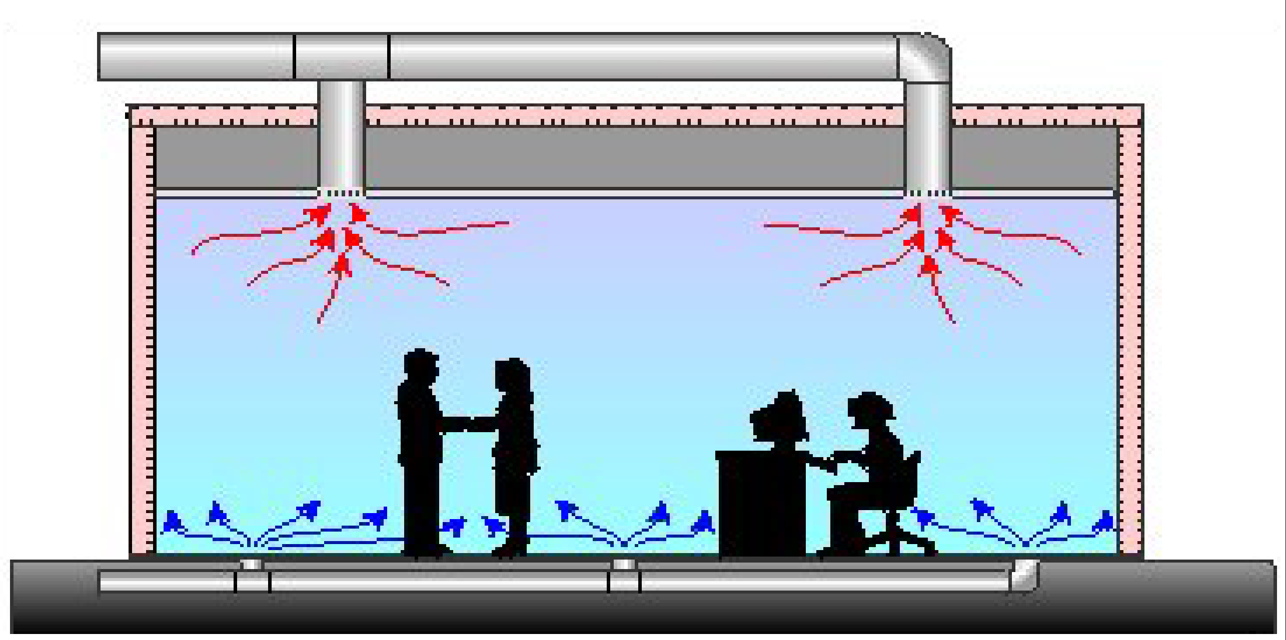
HVAC SYSTEMS

NOTE - AHSRAE 90.1 base system is VAV overhead, well mixed system

<table>
<tr><th>SYSTEM</th><th>DIAGRAM</th><th>PROS</th><th>CONS</th></tr>
<tr><td rowspan="6">VRF</td><td rowspan="6">
</td><td>Energy Savings due to - Variable speed compressors provide high part-load cooling and heating efficiency.</td><td>Not a good application with systems that require high outside air requirements</td></tr>
<tr><td>Energy Savings due to - Reduced fan energy results from low static pressure and elimination of ductwork for space cooling and heating reduces fan energy.</td><td>Obsolescence. VRF technology continues to develop rapidly with respect to control systems and the adoption of new technology, particularly technology to extract as much heat as possible in colder climates.</td></tr>
<tr><td>Energy Savings due to - Refrigerant, rather than water or air, requires less energy to move the heat transfer fluid.</td><td>Troubleshooting and Maintenance. Location and detection of refrigerant leaks can be very difficult with VRF systems. Some factors contributing to this are that the systems tend to be quite large, so it can take weeks or months for a slow refrigerant leak to become apparent.</td></tr>
<tr><td>Energy Savings due to - Some units are capable of heating and cooling at the same time to different zones without reheat and providing heat recovery between zones in heating and cooling at the same time.</td><td>Quality of installation. The spidery nature of VRF pipework, and specific installation requirements (which can vary between different manufacturers), makes the standard of the initial installation a crucial factor in the life expectancy of a VRF system. These are complex refrigeration systems that may have thousands of feet of pipework, hundreds of brazed joints, and hundreds of connecting joints, creating many opportunities for leakage. VRF systems require the same level of care and attention to detail as allocated to large chillers or industrial refrigeration systems. Linesets/Pipework must be supplied to the site cleaned and capped and must remain capped as long as possible. As soon as the installation of a section of pipe has been completed, it should be sealed again to minimize the entry of moisture. The air inside the pipe must be totally replaced by nitrogen during brazing; otherwise a layer of carbon will form on the inner surface of the pipe. Then, once the system is operating, carbon flakes will progressively be released and carried to filters, restricting the refrigerant flow. Special tools and techniques are needed to tighten flare joints to correctly minimize the risk of leakage. Isolation valves with service ports should be fitted to the branch lines for each indoor unit, so that the unit may be repaired or moved without having to decommission and re-evacuate the whole system.</td></tr>
<tr><td>High Level of Adjustability equals generally high level of occupant satisfaction</td><td>Physical leak detection is difficult as the refrigerant pipes are insulated and is even harder where they are run in inaccessible or difficult to access spaces. Also, leaks on internal parts of equipment, such as indoor units, can be difficult to locate without disassembly.</td></tr>
<tr><td>Can achieve up to a 34% energy cost savings (GSA report) relative to code-compliant HVAC system (VAV system per chapter 5 of the GSA design manual)</td><td></td></tr>
<tr><td rowspan="6">Displacement Ventilation</td><td rowspan="6"></td><td>DV provides better acoustics and better air quality than mixed-flow systems. Mixed-flow systems tend to be louder because of the higher velocity required from diffusers. Diffuser noise can be difficult to attenuate. Applying DV diffusers rather than mixed-flow diffusers can reduce sound levels by an NC factor of 5.</td><td>DV cannot be applied as widely as mixed-air systems</td></tr>
<tr><td>Lower supply velocity at diffusers means lower pressure drop, smaller fans, and less energy consumption. Fan horsepower reductions can be attributed to less air movement</td><td>DV can add complexity to supply air ducting</td></tr>
<tr><td>DV can use fewer diffusers and less ductwork</td><td>DV diffusers are more expensive than mixed-flow diffusers</td></tr>
<tr><td>DV introduces supply air at the playing/teaching floor, improving indoor air quality by reducing accumulation of CO2, odor, and indoor contaminants</td><td>Draft risks near units; velocities should always be analyzed</td></tr>
<tr><td>DV has a higher ventilation effectiveness than mixed-flow systems</td><td>Ceiling height must be a minimum of 9 feet, preferably over 10 feet</td></tr>
<tr><td>Free cooling may be available most of the year</td><td></td></tr>
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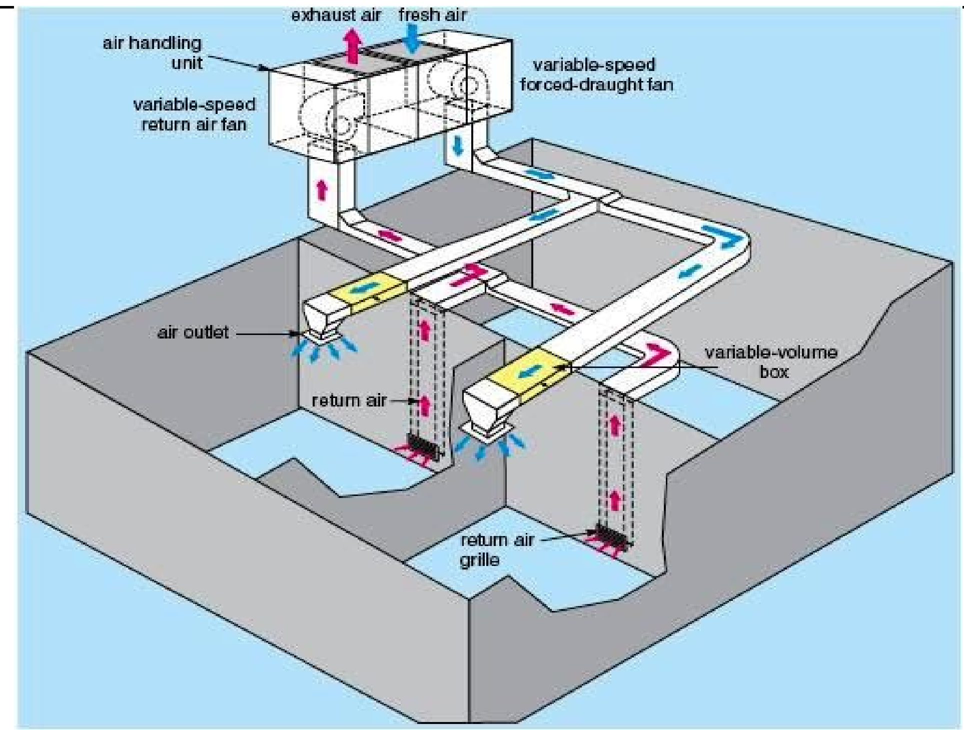
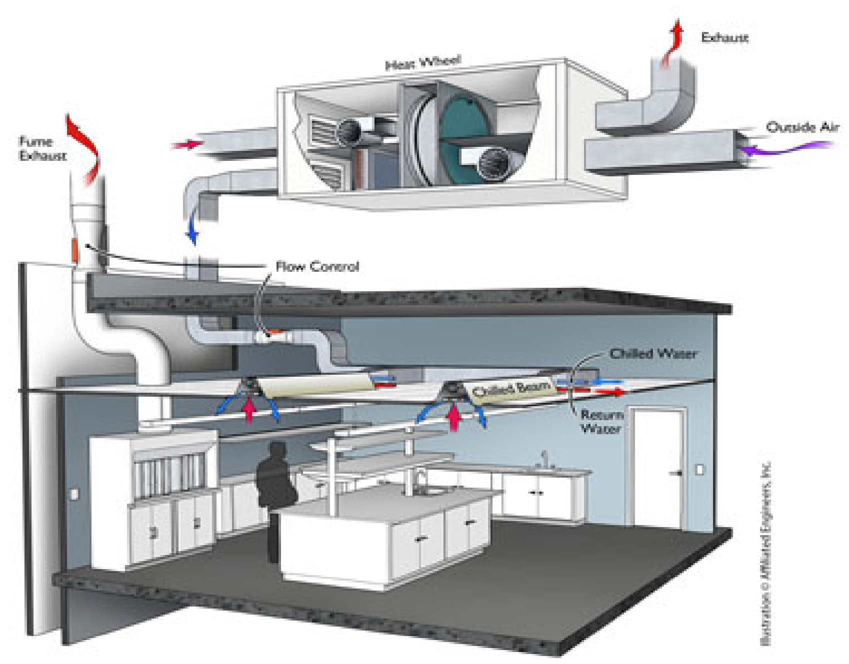
		If 100% outdoor air and exhaust is used, the heat gain due to the lights and roof can be eliminated from building cooling loads.	
		The room neutral temperature for a DV system is higher than that of a conventional mixing system	
VAV		VAV systems are very cost effective from a chilled-water and heating-water-pumping perspective. Because the unit transfers heat to the space using forced convection, the coil heat transfer area required is reduced as compared to a chilled beam. The reduction in coil heat transfer surface area results in lower coil water side pressure drop and lower pumping energy. Forced convection heat transfer also yields higher water side delta T which also results in lower pumping energy	The central air handling unit provides all cooling to the spaces, it is required to move a much greater volume of air. Thus, the floor space required for air handling equipment and vertical duct risers (shafts) is much more significant when compared to the other systems. Ceiling space requirements are also more significant
		VAV systems are excellent systems for serving facilities with occupied interior spaces, because a VAV system can be designed with air side economizer to provide winter cooling to the interior spaces without having to operate the chilled water plant	Generally can only meet the baseline energy use profile under ASHREA 90.1 -
		VAV system can have lower maintenance requirements as compared to the other systems. This is because there is no chilled water coil at the VAV terminal and, where non-fan powered VAV terminal are used, there is no filter at the unit. All the routine maintenance (filter replacement, condensate pan cleaning) is centrally located at the air handling unit, minimizing maintenance needed within the occupied spaces	
Chilled Beam		Commissioning Process is easier	Improper temperatures and high humidity could cause excessive condensation
		Quiet	May limit flexibility of spaces
		Works well when combined with other cooling sources	A single chilled beam cannot serve multiple rooms like a variable air volume terminal, dedicated outside air system terminal or fan coil unit. At least one chilled beam is required for every room
		Energy Efficient - Chilled beams have no terminal unit fan, so overall system fan energy is lower when compared to the other systems requiring terminal equipment fans	Because the entering chilled water temperature must be several degrees above the space dew point, the water side delta T is generally significantly lower than a fan coil unit or variable volume air handling unit delta T. This results in increased pumping energy for the chilled beam system compared to those systems
		More consistent indoor air temperatures	
		Chilled beams have no condensate pan or filter, so the overall system maintenance requirements are reduced compared to systems with terminal equipment filters or condensate pans	A dedicated outdoor air unit is relied upon to provide building humidity control during the cooling season. This is critical to the performance of the chilled beam. The dedicated outdoor air unit must continually provide subcooled/low dew point ventilation air to the building spaces to maintain acceptable humidity levels and prevent condensation at the chilled beams. Any condensation will be noticeable by the occupants and could permanently damage adjacent building finishes
		The system requires minimal air-side infrastructure because central air systems are only required for outdoor air ventilation/primary air. The result is reduced floor space requirement for central air handling equipment and vertical duct risers and greater flexibility in ceiling heights overall	Separate heating systems (e.g., finned tube, radiators, electric baseboard, duct heaters) are often required in heating-dominated climates with a chilled beam system. Chilled beams utilize the reduced density of cold air to induce flow, and are therefore less effective at providing heat to a space