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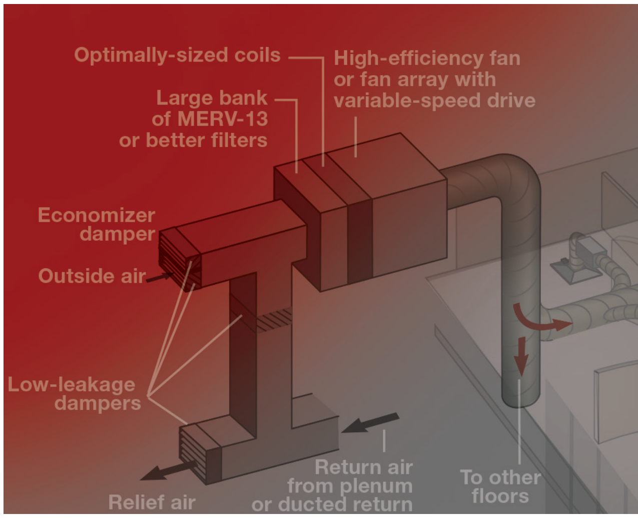
Introducing High Performance Air Systems

An AMCA International White Paper



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Introducing High Performance Air Systems

Ducted HPASs offer significant benefits over ductless systems

ABSTRACT
This white paper will show that a ducted high performance air system, when compared to a ductless water/refrigerant-based system, offers the following benefits:

- **Higher efficiency**
- **Lower first and life cycle costs**
- **Minimal refrigerant risk**
- **Better environmental comfort**
- **Better air filtration**
- **Quieter**
- **Easier to adapt to a new layout**
- **Safer and easier to maintain**
- **System component performance third-party certified by AMCA and AHRI**

HVAC systems in commercial buildings need ventilation. People have increasingly been choosing technologies that prescribe decentralized (unducted) HVAC schemes, which often use dedicated outdoor air systems for ventilation and a variable refrigerant flow system for decentralized heating and cooling. What they may not realize is that systems that use variable air volume (VAV) for centralized (ducted) ventilation is frequently the better choice.

A comparison of ducted versus unducted systems must be made with complete information, and there is an often-ignored modern approach to VAV/ducted systems. A new technology—what is called a high performance air system (HPAS)—earns its name because it performs significantly better than minimally code compliant VAV systems.

INTRODUCTION TO DUCTLESS AND DUCTED SYSTEMS

The following section briefly describes the difference between ductless and ducted systems currently available for installation.

DUCTLESS HVAC: ONE SYSTEM FOR HEATING/COOLING, ANOTHER FOR VENTILATION

Ductless systems pipe a refrigerant or chilled water into occupied spaces for zone heating and cooling. They have a second ventilation air system to meet outside-air code requirements.

Ductless system heating and cooling technologies include

- Variable refrigerant flow (VRF)
- Ground source heat pumps
- Water source heat pumps
- Chilled beams
- Fan coil units
- Ductless system ventilation technologies include
- Dedicated outside air systems with energy recovery
- Makeup air unit
- Natural ventilation

Common applications for ductless installations include

- Existing ductless structures, such as masonry buildings, where ductwork may be expensive to add
- Multi-family housing, dormitories and hotel applications where a common air recirculation is not permitted
- Mixed-use facilities with different zone requirements (for example, with a ducted system serving common hospital areas and a ductless system serving patient rooms)

BENEFITS OF DUCTLESS SYSTEMS

One obvious benefit of this kind of system is the elimination or substantial reduction of ductwork. Another advantage of a ductless system is its compact size and ease of engineering design. The burden of design falls more on the VRF manufacturer and construction supervisor.

HEAT RECOVERY SYSTEMS

Heat recovery systems can be very energy efficient, and VRF systems can be exempt from economizer code requirements. Minimal space, both in the ceiling and inside the building, is required. These systems are also effective in remodel projects.

However, this option can be costly. VRF systems are single-manufacturer driven, meaning that a system is provided by one manufacturer and components from a competing manufacturer cannot be utilized in the repair/modification of the system. With respect to refrigerant capacity, the total capacity of refrigerant in the overall system is greater than the amount allowed by code for indoor air quality.

VRF SYSTEM

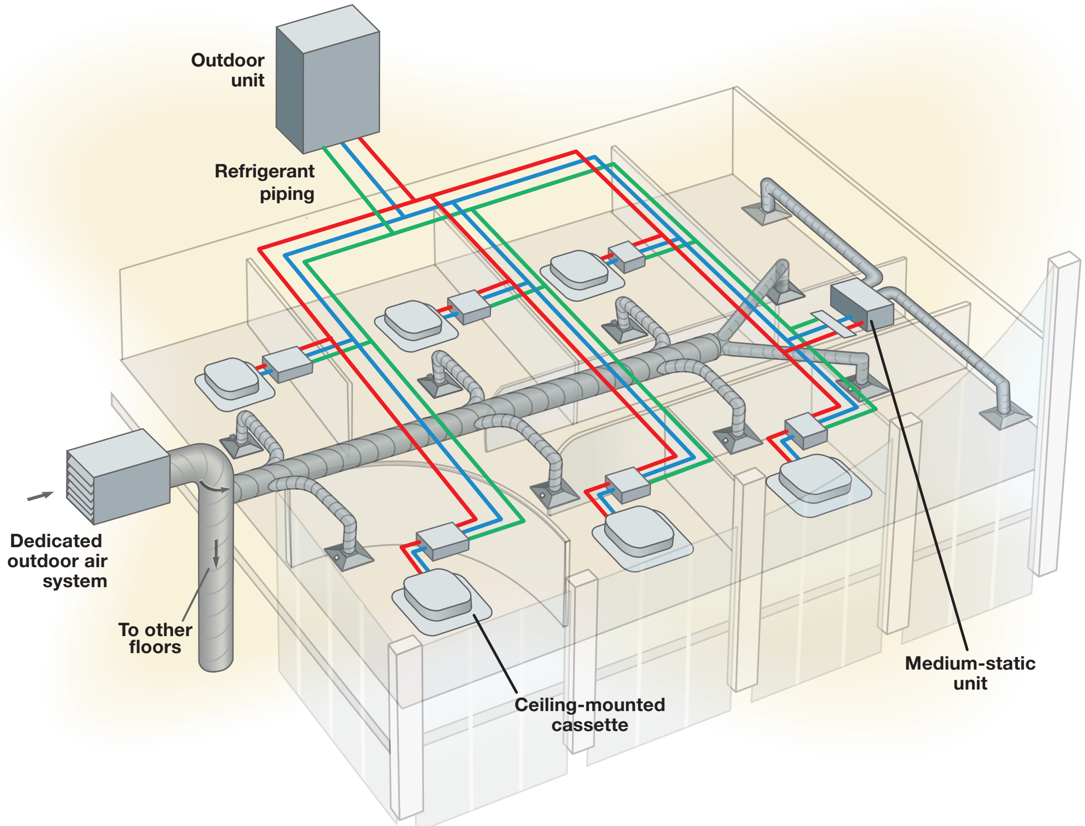

Figure 1: A system using variable refrigerant flow for heating and cooling and a dedicated outdoor air system for ventilation

DUCTED HVAC: ONE INTEGRATED SYSTEM FOR HEATING, COOLING AND VENTILATION

Ducted air-based systems incorporate heating, cooling and ventilation in a single ducted delivery system. Ducted system heating/cooling/ventilation technologies include

- Constant air volume systems
- VAV systems
- HPASs, or VAV systems that optimize energy efficiency, comfort and indoor air quality. VAV systems are inherently efficient and routinely meet model energy codes and standards, such as ASHRAE 90.1[1] and the International Energy Conservation Code.[2] *High performance* VAV systems take things a step further and meet requirements beyond model codes and standards. More information on high efficiency VAVs can be found in "Specifications for High-Efficiency VAV Systems," published by HPAC Engineering.[3]

Some features that can be considered as an enhancement to a typical code-compliant VAV systems are

- Direct digital control (DDC) systems designed and configured per the guidelines set by ASHRAE's guidance document entitled "High Performance Sequences of Operation for HVAC Systems" (ASHRAE GPC 36, RP-1455)
- A DDC system that integrates a fault detection and diagnostics system
- More efficient chillers and heating boilers, due to a central heating or cooling plant

Common applications for ducted installations include

- Commercial buildings, such as offices, retail facilities, restaurants, theaters and casinos
- Factories
- Schools and education buildings
- Hospitals and healthcare facilities
- Laboratories and research facilities
- Common areas of mixed-use facilities

WHAT IS A HIGH PERFORMANCE AIR SYSTEM?

HPASs earn their "high performance" name because they perform significantly better than minimally code compliant VAV systems. HPASs are what specifiers choose when looking for energy efficiency, comfort and indoor air quality.

HPAS design integrates the strategies of right-sizing, zone optimization and outside-air-based free cooling. HPASs also minimize static pressure drop, system leakage and system effects.

SUPPORTING MATERIAL

A white paper published in March of 2016 by Bell and Gossett[6] compared hydronic systems to VRF. According to this paper, the lifetime of a VRF systems is only 10 to 15 years, and there exists

- A lack of research, even from historically strong VRF regions
- A lack of VRF flexibility pertaining to changing building occupancy
- A lack of energy storage
- A reliance on local skills for soldering and brazing and high-pressure leak testing
- Proprietary protocols among VRF manufacturers
- Building heights restricted to 10 stories due to pipe length runs (and note that the alternative of multiple VRF systems is costly)

HIGH PERFORMANCE AIR SYSTEM

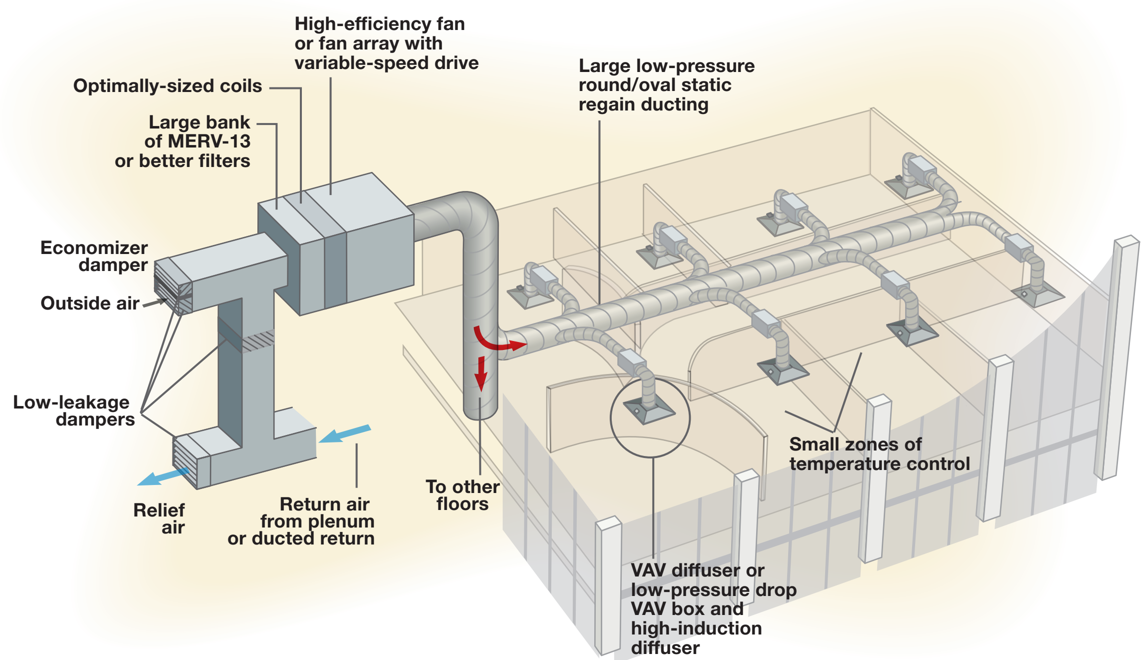

Figure 2: A ducted high performance air system

HPAS technologies and strategies include

- Variable air volume
- Small temperature control zones
- High efficiency fans
- Either outside air economizers or waterside economizers, providing free cooling for a significant portion of the year. Note: this means the compressors providing the cooling can be completely shut off. Plus, during these times, indoor air quality is typically enhanced because there is more outside air being brought into the space
- Air-to-air energy recovery (an important HPAS strategy that is also common to other HVAC system types)
- Low leakage dampers and ducts, spiral/oval static regain ducting
- Low-pressure-drop components
- Variable flow compressors
- Diagnostic sensors for monitoring the system's performance

BENEFITS OF A HIGH PERFORMANCE AIR SYSTEM

HIGH ENERGY EFFICIENCY. The most prominent benefit of a high performance air system is energy efficiency.

LOW LIFE CYCLE COSTS. An HPAS's high energy efficiency leads to low life cycle cost; it is, in fact, the largest contributor to cutting down on costs over the lifetime of the equipment. Cooling energy cost savings are significant, since free cooling and lower fan heat requires less cooling. Fan energy savings are also significant due to a lower system design static pressure (fan external total pressure). Continuous automated monitoring systems can lower life cycle costs by identifying operational events that could affect building performance. It should be noted that, in addition to saving energy, the benefits of a VAV zone per occupant include higher worker productivity and improved ability to lease the space. Expensive office workers are more productive without the distraction of being uncomfortable. Also, offering a thermostat for each occupant increases the appeal of office space, attracting lessees. These benefits should be included in payback calculations.

LOW FIRST COSTS. Integrated heating, cooling and ventilation systems typically have lower first costs than ductless systems, though this depends on variables such as location and equipment. Ductless systems combine first costs for two systems: heating/cooling and ventilation.

CENTRALIZED REFRIGERANT SYSTEMS MINIMIZE RISK. Refrigerant leakage in occupied spaces is a safety issue for many ductless technologies, but not for high performance air systems. In an HPAS, refrigerant is centralized in an equipment room or rooftop unit instead of in the room, above the ceiling or in an adjacent closet. There is a limited minimum size of the zone where refrigerant is in occupied spaces, precluding small temperature control zones. Codes (ANSI/ASHRAE Standards 15 and 34[4]) require a maximum of four kilograms of R-410A per 10 cubic meters (25 pounds of R-410A per 1000 cubic feet) of room volume for non-institutional spaces. Transfer ducts between rooms may be required.

In addition, when any system contains more than 50 kilograms (110 pounds) of refrigerant, fusible plugs must be discharged to the atmosphere at a location not less than 4.6 meters (15 feet) above adjoining ground level and not less than six meters (20 feet) from any window, ventilation opening or exit (per ANSI/ASHRAE Standards 15 and 34 and local codes). Accomplishing this is easier when the refrigerant system is centralized.

MULTIPLE SMALL ZONES IMPROVE COMFORT, FLEXIBILITY AND EFFICIENCY. An HPAS has small temperature control zones, which can be the size of one office. A refrigerant-based system temperature control zone must be large enough to safely disperse a full system refrigerant charge if there is a leak in that zone (per ANSI/ASHRAE Standards 15 and 34). Note that a maximum of four kilograms of R-410A per 10 cubic meters (25 pounds of R-410A per 1000 cubic feet) of room volume is allowed for non-institutional spaces. The usual VRF system charge is 0.3 to 0.6 kilograms of R-410A per kilowatt (three to six pounds of R-410A per ton) of refrigeration. When this charge exceeds four kilograms of R-410A per 10 cubic meters (25 pounds of R-410A per 1000 cubic feet) in any room, multiple rooms typically need to be grouped together to be served safely by a single terminal unit, increasing the temperature control zone size of a ductless system.

HPAS VERSUS DUCTED: INSTALLED SYSTEM BENEFITS

BETTER AIR FILTRATION. An HPAS uses MERV-13 (or better) filters and UV surface cleaning, which provides higher quality filtration than the residential-type filters commonly used in ductless systems.

QUIETER. HPAS fans and compressors are quieter in a central location well away from occupied spaces, whereas ductless systems have noisier small room and ceiling fans.

MORE ADAPTABLE. Small zones easily adapt to moved walls or other office layout changes. When needed, it is easier to move diffusers and duct takeoff branches than it is to move fan coil units and refrigerant lines.

SAFE AND EASY MAINTENANCE. Many high performance air systems require no scheduled maintenance in occupied spaces. The parts of an HPAS needing the most service (compressor, fan and filters) are all in a central location, either on the roof or in an equipment room, away from occupants and easily accessible at any time for maintenance. In contrast, ductless systems require indoor unit filter replacement, coil cleaning and visual condensate drain inspection for every indoor fan coil on a scheduled basis. Above-ceiling maintenance, condensate pan overflow risk and refrigerant leaks can result in ceiling damage and health hazards for occupants.

COMPONENT PERFORMANCE IS THIRD-PARTY CERTIFIED BY AMCA AND AHRI. Most HPAS components are certified by the Air Movement and Control Association (AMCA) and the Air-Conditioning, Heating and Refrigeration Institute (AHRI), assuring owners that performance meets specified levels. AHRI-certified thermal performance covers refrigeration system efficiency, depending on the type of product. AMCA certifies ratings test data for air performance, sound levels, weather-resistance, air leakage and other parameters. An example of an AMCA Certified Ratings Program seal is shown in Figure 3.

Figure 3: AMCA's seal certifying a high level of air performance

AMCA published a series of white papers[5] on the AMCA Certified Ratings Program that provide summaries of the program and guideline specifications for requiring AMCA-certified products for projects.

HOW HIGH PERFORMANCE AIR SYSTEMS BOOST EFFICIENCY

Several energy-reducing features distinguish high performance air systems.

OPTIMIZED FANS, REDUCED PRESSURE DROP. To lower fan energy consumption, system designers achieve the best airflow performance by selecting the fan with the lowest power (which is not always the lowest cost or the smallest fan). Manufacturers of air handling units, rooftops and fans have selection programs that help designers meet airflow and system pressure requirements. Further optimization results from lowering design supply air temperature, specifying low leakage spiral/oval ducting and not oversizing design loads.

Other high performance features include design of lower-pressure-drop air systems using optimized coils, large filter banks, round or oval ductwork designed to use static regain, low-pressure-drop terminals, and plenum returns.

More optimization is delivered when selecting efficient variable speed motors and drives for part load energy savings. A variable-speed drive could be used to reduce the motor speed. As a result, consumed energy is dramatically lower. A fan needed to deliver one-half the design airflow with optimized control can operate with nearly one-eighth the design power.

Cooling and heating for HPASs is provided either by a high efficiency chiller/boiler combination or a gas-fired high energy efficiency ratio VAV rooftop unit.

FREE COOLING. Today's tight building envelopes with high occupant densities and internal loads require year-round cooling in interior zones. HPASs bring in free, cool air when outside temperatures are low. Compare this to the energy use of ductless systems that must always run compressors to satisfy cooling demand.

SOPHISTICATED CONTROL. HPAS advanced control technologies increase energy savings further through

- Ventilation optimization based on fresh air demand by zone
- Comparative enthalpy economizers with remote indication depending on the climate zone the system operates within
- Supply air temperature reset tied to measured system demand
- Optimum start/stop
- Static pressure set point reset based on zone demand
- Reduced VAV terminal minimum airflows
- Variable speed compressors and fans
- Low-cost, efficient gas heating systems
- Trending, fault detection, diagnostics, alarm reporting and networked controls for scheduling and auto-reset of set points
- Adaptability to smart-grid technologies such as demand reduction, remote monitoring, automatic response to grid failures and degradation, etc.
- User-specific building automation control strategies, such as operating HVAC equipment to its greatest potential and simplifying setup. Other control strategies include documented operation sequencing and providing information required for service
- Airflow measurement and control using intelligent solutions that incorporate thermal dispersion technology with microprocessor based controls
- Ice and chilled water thermal energy storage in the building that reduces peak demand and shifts the cooling load to times of cooler outside air. Additionally, the nighttime use of compressors for making ice and cold water storage uses electricity when wind power is typically at peak generation
- Pre-cooling with economizer flush at night

CONCLUSION

Ducted and ductless systems differ in a number of ways. When evaluating which of these system is most appropriate for a project, high performance air systems bear special consideration. HPASs perform significantly better than minimally code compliant VAV systems, making them well-deserving of their "high efficiency" name. They optimize energy efficiency, comfort and indoor air quality while focusing on right-sizing, zone optimization and outside-air-based free cooling. HPASs also minimize static pressure drop, system leakage and system effects.

When considering design approaches for ventilation systems, be sure to consider an HPAS over traditional VAV approaches and non-ducted systems.

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