WaterFurnace
Commercial Solutions

# Space Conditioning Control

## A New Approach to Space Dehumidification

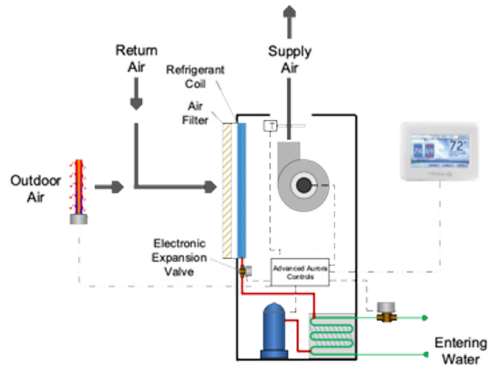

## Abstract

**Utilizing Variable Speed compressor and blower technology to efficiently provide variable sensible and latent cooling capacities in space conditioning applications.**


## Introduction

The design of an air conditioning system creates an inherent challenge in that it is sized based upon conditions that occur less than five percent of the time annually. Operating an air conditioning system at part load conditions can create an additional challenge if the sensible or dry bulb temperature component of the total air conditioning load is met too quickly. Higher moisture levels remain when the system is cycled in part load operation. In order to control indoor temperature and humidity at appropriate levels for occupant comfort and indoor air quality (IAQ), excess humidity which represents the latent or wet bulb temperature component of the total air conditioning load must be removed from the air.

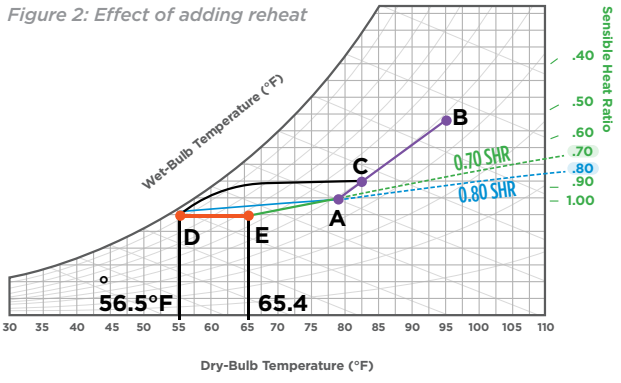
*Figure 1: Schematic of a Variable Speed water source heat pump*




Traditionally, reheating the air leaving the air conditioning system has become the industry standard solution to controlling humidity (Figure 1). The air returning from the conditioned space is cooled well below the dew point in order to condense as much moisture from the air as possible and then it is reheated to a higher temperature, helping to prevent overcooling, before being sent back to the conditioned space. This process requires additional energy to sub-cool the air as well as provide the heat required to temper the conditioned supply air. The source of heat for reheating may be supplied by: electric resistance, hot water, recirculated condenser water, heat recovery from exhaust air or superheated refrigerant. It should be noted that electric reheat has been eliminated in ASHRAE 90.1 and that recirculated condenser water decreases a water source heat pumps (wshp) cooling efficiency due to the elevated condensing temperature required to provide effective reheat.

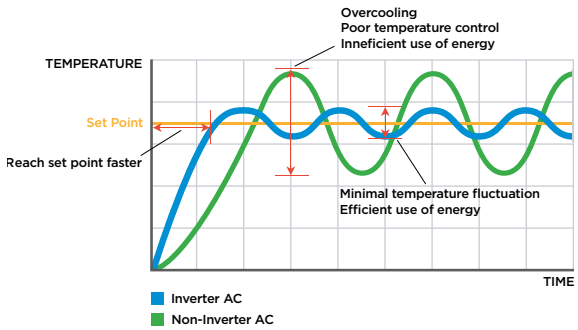
Water source, direct expansion (DX) air conditioning systems have typically relied upon refrigerant for their hot gas reheat (HGRH) systems to control humidity. Single-speed compressors and supply air fans proved to be the limiting factors in helping to provide more precise humidity control which led to the development of modulating HGRH that allowed more control over the amount of heat supplied during reheat (Figure 2).

*Figure 2: Effect of adding reheat*



WaterFurnace is ushering in a new era of Variable Speed motor and Aurora Advanced controls technologies to water source heat pumps. Using rare earth, permanent magnet DC motors, both the compressor and supply fan speeds are able to be modulated in order to more closely match the cooling load profile of the conditioned space. Coupled with advanced temperature, humidity, refrigeration performance and energy efficiency controls capabilities, the Versatec® Variable Speed series of units provide the versatility to alter the unit's ability to respond independently to changes in either sensible or latent cooling loads within the conditioned space (Figure 3).

*Figure 3: Precise control with Variable Speed WSHP*

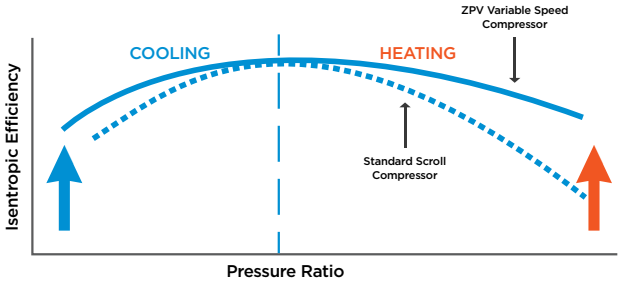



## Technology Spotlight

Utilizing variable frequency drives (VFD) on compressors to vary capacity is not a new concept. However, the approach taken by WaterFurnace was to couple a recently redesigned Copeland scroll compressor to improve part load efficiency with variable volume ratio (VVR) and an electrically commutated motor (ECM) with an Emerson inverter. The compressor motor utilizes DC electric current which provides 4:1 capacity turndown outperforming inverter driven compressors utilizing AC electricity (Figure 4).

*Product images courtesy of Emerson Electric Co.*

*Figure 4: Variable Volume Ratio and High Efficiency Valve Effect*




The Aurora Advanced Variable Speed Controls uses internal PID control sequences for the compressor speed drive, electronic expansion valve and fan speed drive to provide capacity and superheat control of the unit electronically. In addition, energy monitoring is a standard feature where current transducers measure electrical current and power of the compressor and fan motor. These advanced controls allow unparalleled information and ease of operation previously unavailable to WSHP's.

The "Active Dehumidification" mode is only active when the unit is in the cooling mode of operation as it is intended to provide enhanced humidity control in non-critical space conditioning applications. It is activated when the humidity level being sensed is 5% above the humidity setpoint. The fan will be commanded to its low speed setting (field adjustable) and the compressor begins to stage up to a speed greater than 50% of the full load capacity. The supply air fan and compressor speeds will be adjusted independently of each other to optimize the unit's performance based upon the sensible and latent cooling loads of the conditioned space. If, after 20 minutes of Active Dehumidification mode operation, the humidity set point has not been satisfied, the unit will be placed back into normal cooling mode for a period of 5 minutes. This sequence of operation will continue until the humidity set point has been satisfied, the space temperature is driven more than 2°F below cooling set point, or more than 1°F above cooling set point (normal cooling takes over).

Comparing a standard efficiency water source heat pump utilizing hot gas reheat with a Versatec Variable Speed WSHP in dehumidification operation, there are several key differences in unit performance. First, the sensible cooling capacity of the Variable Speed unit is reduced by running the compressor and fan at lower speeds while the latent cooling capacity increases. The impact to the Variable Speed unit's ability to remove moisture from the space is significantly increased. Electrical input to the Variable Speed unit is greatly reduced compared to a standard WSHP

*Figure 5: WSHP Cooling Operation with and without Dehumidification*

| | **Versatec Ultra** 3 ton Unit | | **Versatec Variable Speed** 3 ton Unit | |
|---|---|---|---|---|
| | **Without Reheat** | **With Active Dehumidification** | **Without Reheat** | **With Active Dehumidification** |
| **Total Cooling** | 33,320 | 31,987 | 36,710 | 28,042 |
| **Sensible Cooling** | 23,710 | 19,205 | 25,870 | 15,811 |
| **S/T** | 0.71 | 0.60 | 0.70 | 0.56 |
| **Latent Cooling** | 9,610 | 9,592 | 10,840 | 12,230 |
| **Moisture Removal** | 9.0 | 9.0 | 10.1 | 11.4 |
| **Input Power (kW)** | 2.47 | 2.43 | 2.22 | 1.61 |
| **Heat of Rejection** | 41,700 | 39,657 | 44,300 | 33,095 |
| **EER** | 13.5 | 13.2 | 16.5 | 17.4 |

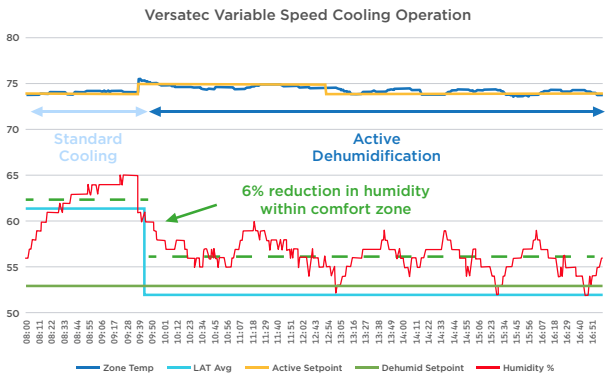
Entering Air 74°F / 63°F

thereby increasing the operating efficiency. This is a result of the lower electrical consumption by the compressor and fan as well as eliminating the wasted heat used for reheating the discharge air (Figure 5).

Because WSHP's are sized for design conditions that will not frequently exist, oversizing the cooling capacity increases the potential for issues with humidity and comfort control. The Versatec Variable Speed compressor and fan allow the unit to actively respond to changes in either sensible or latent cooling loads unlike traditional fixed capacity WSHP's. Despite operating at nearly twice the amount of time as the standard WSHP, the Variable Speed unit consumes less electrical energy. In addition, the amount of waste heat rejected by the Variable Speed unit is reduced further conserving energy required by the Net Energy Water Loop (condenser water loop, geothermal ground loop or hybrid loop) to remove (Figure 6).

*Figure 6: Active Dehumidification*

- Zone space temperature maintained within 1 degree of set point
- Average leaving air temperature of 52F degrees
- 6% decrease in zone humidity
- No reheat required
- Within ASHRAE Standard 55-2017 Comfort Zone
- Data shown collected by Symphony CloudLink




## Conclusion

The Versatec's Variable Speed design provides superior overall WSHP performance over fixed capacity units with reheat while closely maintaining space conditioning comfort for occupants. The ability to vary the capacity of the compressor and fan independently provides the ability to modulate the sensible and latent cooling capacity to the needs of the conditioned space. The added advantage of this strategy is that wasted energy used for reheat is eliminated and the amount of rejected heat to the net energy water loop is significantly reduced improving the overall system efficiency. Because the fan is turned off for 180 seconds and the compressor operates at the lowest speed between Active Dehumidification cycles, there is no re-evaporation of condensate that is typical with reheat of DX air conditioning systems.

The Aurora Advanced controls platform is integrated into the Variable Speed WSHP design featuring modulated capacity control between 25-100% utilizing multiple-input multiple-output (MIMO) controls that adapts to varied load conditions without a separate reheat circuit being controlled by single-input single-output (SISO) strategy. The sophistication of this controls platform provides the capability to monitor the refrigeration circuit performance, electrical consumption of the compressor and the fan, while seamlessly providing this critical information to the system operator.

*Learn more at **waterfurnace.com/Commercial***

Other References:
https://docs.lib.purdue.edu/me/
2008 Purdue e-Pub: *"A New Control Approach for a Direct Expansion (DX) Air Conditioning (A/C) System with Variable Speed Compressor and Variable Speed Supply Fan"*



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