WHITE PAPER #:

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THE SMART SOLUTION FOR ENERGY EFFICIENCY

CLIMATEMASTER KNOWLEDGE SERIES: 100% OUTDOOR AIR DEHUMIDIFIER CONTROL STRATEGIES

CLIMATEMASTER®

WATER-SOURCE HEAT PUMP SYSTEMS

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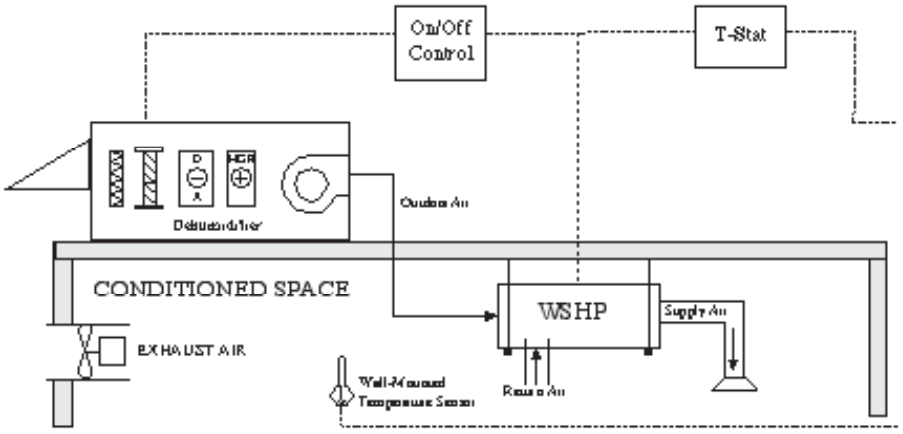
Introduction

As consulting engineers and end users implement ASHRAE 62, they must select the appropriate temperature control method for introducing outdoor air while eliminating humidity within the conditioned space. This bulletin will describe the control options available for maintaining comfortable indoor conditions while introducing outside air that meets the ASHRAE ventilation code. Since the control methods described here vary in complexity and cost, the benefits of each will be explained to provide you some guidelines for selecting the most economical system for your application.

Figure 1: Diagram of a dehumidifier supplying conditioned outdoor air to an air handling unit using on/off control



Equipment Options

To control leaving air temperature (LAT), makeup air dehumidifiers use various strategies to reheat the supply air after it has been dehumidified. Three of these methods include liquid subcooling reheat, hot gas reheat and auxiliary heat.

1. Liquid Subcooling Reheat

As the dehumidifier captures both sensible and latent heat during moisture removal, the compressed hot gas refrigerant is directed to a condenser (either air-cooled or water-cooled) to dissipate much of this heat. After releasing its heat, the gas becomes a warm liquid refrigerant and returns to the receiver. However, it still contains a considerable amount of usable heat for reheat purposes. This warm liquid refrigerant can be directed to a reheat coil where it can raise the LAT to between 57°F [14°C] and 85°F [29°C]. Unfortunately, the temperature is not adjustable. It is dependent on the amount of energy in the outdoor air being dehumidified.

If the LAT is too warm, a valve will close and cause the warm liquid to bypass the reheat coil, allowing the system to provide cool air. Since the reheat coil in this system must be fully on or off, the LAT can swing substantially.

2. Modulated Hot Gas Reheat

Another strategy uses hot gas refrigerant to reheat the dehumidified air. Air flows over a reheat coil which contains hot gas. Since hot gas contains a significant amount of energy, it can reheat supply air to a set point as high as 80°F [27°C] regardless of entering air conditions. Conversely, by limiting reheat, the LAT can reach a cooling set point as low as 50°F [10°C]. A modulating valve is used to control the flow of hot gas through the coil and maintain the desired LAT even as entering air conditions change. The LAT swings that are characteristic of liquid subcooling are avoided.

3. Auxiliary Heat Sources

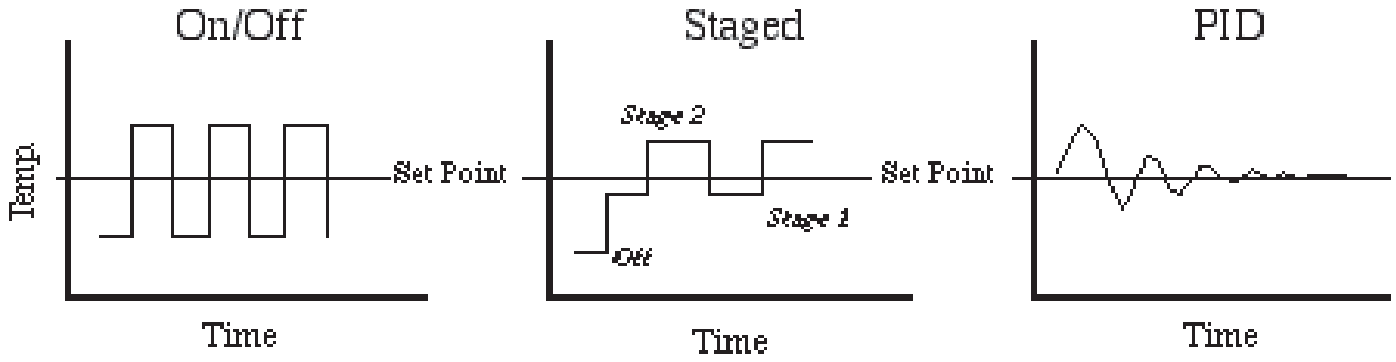
When a dehumidifier's refrigeration circuit is active, it can reheat makeup air with excess heat recovered from the moisture removal process. Once the outdoor temperature and humidity drop, makeup air no longer needs to be dehumidified, but it must still be brought into the space. Auxiliary heat is then required to heat the cold outdoor air to the desired temperature. This heat can be provided by way of hot water or steam, electric coils or gas burners.

Whether the auxiliary heat is packaged with the dehumidifier or provided by others, it will normally cost more if precise temperature control is necessary. Regardless of which heat source you choose, there are several categories of temperature control available:

- On/Off Control - As its name suggests, this heat source is either fully on or off. The LAT will swing as the heater cycles on and off to maintain a desired set point.
- Staged Control - This method is more precise than on/off control. The controller will energize multiple stages of heating as needed to satisfy the set point. While the LAT will still vary, the fluctuations are less extreme than with the on/off control.
- Modulating Proportional, Integral, Derivative (PID) Control - With this approach, a sensor is placed in the supply air duct that provides feedback control to a special modulating valve. This is the most precise way to match the heating output to the set point.

The diagrams in figure 2 show the effect that the different control strategies can have on LAT. Note that the modulating control strategy ultimately results in the most accurate LAT control.

Figure 2: Diagrams showing the effect of different Auxiliary Heat Control Strategies



Temperature Control Options
There are numerous makeup air temperature control strategies. Three popular control variations are room control, leaving air temperature (LAT) control and room reset of LAT.

1. Room Control

This strategy uses a single wall-mounted sensor to maintain the desired temperature in the conditioned space. Heating or cooling is energized when the space air temperature moves away from the set point. Because of the large mass of air in the room, the supply air temperature may need to be much hotter or colder than the actual room temperature to drive it closer to its set point. Modulating control of heating is not normally required for room control. Simple on/off controls of the reheat should be sufficient. Refer to Figure 1.

Because LAT may swing widely, supply grilles must be installed where they won't blow air directly on any occupants. Room control is most economical for comfort conditioning purposes in spaces where the system provides less than five air turns per hour. The large room volume (mass) acts as a buffer to quick changes in room temperature.

2. Leaving Air Temperature (LAT) Control

A LAT approach uses a single duct-mounted sensor to maintain the desired temperature of the supply air. Because the air mass in the supply duct is relatively low and is moving rapidly, the auxiliary heat must respond quickly to changes in the set point.

On/off or staged systems cycle rapidly because their steps or stages are too extreme for the level of control required. Such rapid cycling will reduce the service life of the refrigeration circuit and the heater and its components. Modulating controls can make the small incremental changes necessary to maintain tight control. Using staged or modulating controls on reheat and auxiliary heaters will help extend the life of the system while providing more uniform supply air temperatures.

LAT control is not necessary when a makeup air dehumidifier is supplying conditioned outdoor air to an air handling unit. However, the modulating control can save significant "system" energy and may be preferred over on/off control in this application. When a makeup air dehumidifier is supplying air directly to a conditioned space, LAT control eliminates the drafts commonly felt with on/off systems. Likewise, LAT control is also ideal in industrial applications that require precise air temperatures. Refer to Figure 3.

3. Room Reset of LAT

This strategy combines a wall-mounted sensor with a duct-mounted sensor to maintain the desired temperature in the conditioned space. Heating or cooling will be activated when the air temperature shifts away from the set point. However, unlike the room control strategy, the controller varies the LAT within a fixed range to maintain the room set point. This particular system is especially helpful at preventing overheating or overcooling of a space that is influenced by other energy sources such as solar gain or loss through windows.

This strategy works best when modulating controls are used with an auxiliary heat source and a dehumidifier reheat coil, as is the case with a modulating hot gas reheat system. Refer to Figure 4 and Figure 5.

Room reset of LAT provides the greatest control over temperature and comfort and is especially helpful in spaces with more than five air turns per hour. It helps conserve energy by preventing overheating or overcooling of the conditioned space. Because this method gradually adjusts room temperature, hot and cold drafts are virtually eliminated. This produces more comfortable surroundings for occupants and a more stable environment for temperature-sensitive equipment.

Figure 3: LAT Control configuration

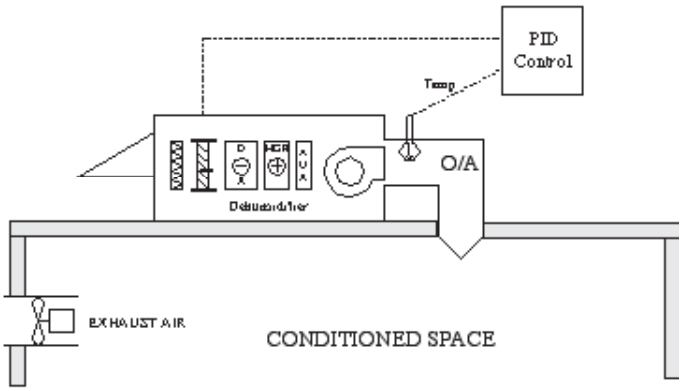
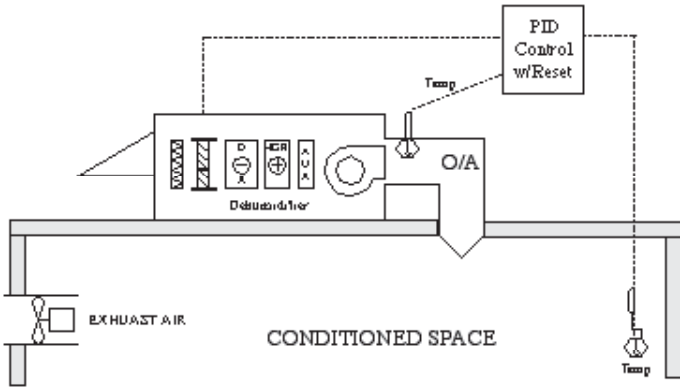


Figure 4: Room Reset of LAT Control configuration



Equipment Selection
Use table 1 to quickly select the most economical equipment and control strategy for your application. Note that a dehumidifier is not considered a “standalone” if it is combined with another heating or cooling system with its own set of temperature controls. Also notice that this table lists the most cost-effective strategies. There may be other combinations of equipment and control sequences that will be more expensive but will certainly work for your situation.

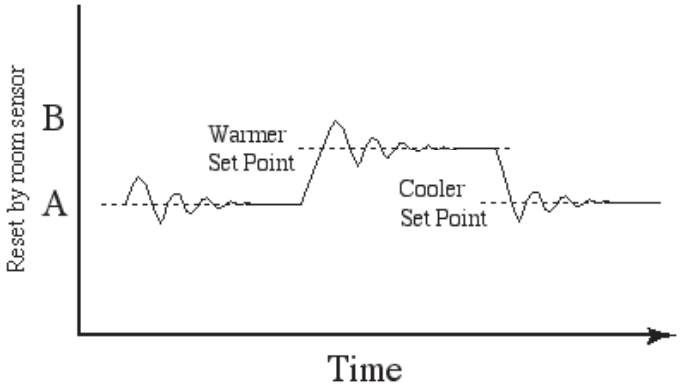
Using this information will help ensure that your dehumidifier performs as it was intended - to maintain occupant comfort and maximize system efficiency while meeting ASHRAE 62 ventilation specifications.

While a dehumidifier primarily focuses on heating air, the unit provides a secondary benefit in the cooling mode. Should the space temperature rise above the set point, the 100% outside air dehumidifier can switch to the cooling mode and reject the resulting heat to the water loop. Because the dehumidifier assumes a large portion of the cooling load, the size of the main heating / cooling system can be reduced proportionally and act as second stage cooling.

A fixed reheat system (such as liquid subcooling) will use a temperature sensor in the space. This controls a three-way valve in the refrigerant system that prevents any reheat to occur. As a result, cold air is delivered to the space to provide air conditioning.

A modulating hot gas reheat system will add a temperature sensor to the space and rely on room reset of LAT type of control. This combination will vary the discharge temperature to maintain the space conditions.

Figure 5: Effect of a Room Reset of LAT Control



Conclusion
The design engineer who implements ASHRAE 62 ventilation requirements is most concerned about occupant comfort and moisture control. Removing moisture from outside air provides a cost-effective way to prevent moisture-related IAQ problems. Applying the proper temperature control strategy further enhances the effectiveness of the outdoor air treatment system by precisely controlling the temperature of the air being delivered to the space.

To select the most economical temperature control system, the design engineer must take into consideration the size, layout and fresh air requirements of each application. The proper temperature control strategy will offer substantial energy savings which, in the long run, will ultimately offset the capital cost of installation. With the appropriate dehumidifier and control system in place, a facility can provide its occupants the required level of comfortable, conditioned ventilation air while simultaneously conserving energy.

Table 1: Recommended equipment and control method for various applications

Application	Hourly Air Turns	Standalone Systems	Recommended Model	Types of Auxiliary Heat	Control Method
Comfort Conditioning	Five or Fewer	Yes	Any	On/Off or Staged	Room Control
		No	Liquid Reheat	On/Off or Staged	LAT Control
Comfort Conditioning	Five or More	Yes	Hot Gas Reheat	Modulating	Room Reset of LAT
		No	Liquid Reheat	On/Off or Staged	LAT Control
Process Control	Any	Yes	Hot Gas Reheat	Modulating	LAT Control

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