

HUMIDI-MIZER® ADAPTIVE DEHUMIDIFICATION SYSTEM FOR APPLIED ROOFTOP UNITS

**WeatherMaker® 48/50A
WeatherMaster® 48/50P
WeatherExpert® 48/50N**

**Expanded Applications for
Packaged Rooftop Units**



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**Carrier Corporation
Syracuse, New York**

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INTRODUCTION

Packaged rooftop units are currently being implemented in many applications that require a high degree of indoor comfort and humidity control. This trend reflects the expanding use of packaged rooftop units for applications that were traditionally served by built-up customized systems. The Carrier Humidi-MiZer® adaptive dehumidification system for applied rooftop units (20 to 150 tons) is a factory-installed option that expands the operating capabilities of the traditional direct expansion (DX) packaged large rooftop unit.

The goal of maintaining indoor space humidity levels throughout the year, regardless of the geographical location, internal level of moisture generation and outdoor air circulation constraints is a difficult task. In order to accomplish this goal, the equipment must be able to meet a variety of indoor sensible and latent load requirements. It is of particular importance that the equipment have the flexibility to meet these requirements when the thermal load is less than the thermal load at the design conditions (i.e., at part load operation). Standard product enhancements cannot always meet these requirements, as the equipment may inefficiently treat a higher volume of outdoor air, or consume additional energy by trying to control humidity levels by overcooling a space. Carrier's Humidi-MiZer adaptive dehumidification system can help owners meet the demand for providing a flexible and high performing solution to accommodate all of these design related issues.

HUMIDI-MZER ADAPTIVE DEHUMIDIFICATION SYSTEM

Unlike typical hot-gas reheat (HGRH) dehumidification options, the Humidi-MiZer adaptive dehumidification system also provides the

flexibility to meet part load requirements when simultaneous temperature and humidity control is desired. Using an industry exclusive subcooling method, the Humidi-MiZer system increases the latent capacity of the unit, while still allowing the capability to dehumidify without overcooling the space. When part load situations require both cooling and dehumidification, a conventional HGRH system will cycle between the normal mode (cooling only) and the HGRH mode (dehumidification only), a relatively inefficient approach. In part load situations, the Humidi-MiZer system has the capability to automatically adjust the sensible heat ratio (SHR) at which the equipment operates to meet the demand of the space by lowering the evaporator air discharge temperature to meet the latent load and reheating the air to the supply air set point. The Carrier applied rooftop version of Carrier's Humidi-MiZer system includes refrigerant modulating valves that provide variable flow bypass around the condenser. This innovative feature ensures exact control of the supply-air temperature as the unit lowers the evaporator temperature to increase latent capacity. Additionally, when the space requires dehumidification only, the Humidi-MiZer system can increase hot discharge gas bypass to the Humidi-MiZer system coil in order to heat the air to the exact neutral state required – no overcooling or overheating, with similar latent capacity as provided in the full subcooling mode. The benefit to occupants is a more constant space temperature and humidity level, while limiting short cycling of the rooftop unit. The Carrier applied rooftop unit takes the Humidi-MiZer system to the next level, providing a nearly infinite spectrum of sensible heat ratios (SHR) to meet the needs of varying space loads.

FEATURES/BENEFITS

The Humidi-MiZer® adaptive dehumidification system in a packaged rooftop product provides a great degree of operational flexibility and superior humidity control for consistently maintaining year-round indoor comfort temperature and humidity levels. The Humidi-MiZer adaptive dehumidification system benefits include:

Maximum Flexibility

Using three operational modes and modulating refrigerant bypass valves, the system is better able to adapt to all peak and part load conditions with respect to outdoor temperature and humidity level.

Consistent Comfort

System operational flexibility allows the rooftop unit to maintain both indoor temperature and humidity comfort conditions consistently year round.

Superior Humidity Control

When maximum humidity control is required in the space, Carrier's exclusive reheat design sequence simultaneously provides neutral air (or any other desired temperature level) and dehumidification of the space.

Cost Effectiveness

- Available as a factory-installed option on the 48/50A, 48/50P, and 48/50N product lines, the Humidi-MiZer adaptive dehumidification system provides a cost effective packaged alternative for meeting the requirements of applications with significant latent loads. System installation is simplified and costs are minimized by using factory-installed return air sensors or accessory space sensors, or by accepting a discrete input from a mechanical humidistat or third party controller.

TYPICAL APPLICATIONS

Many applications can benefit from utilizing the Humidi-MiZer adaptive dehumidification system. The following applications exhibit conditions in which the Humidi-MiZer adaptive dehumidification system would be an ideal enhancement to an applied rooftop unit.

Schools

Variable student occupancy, with constant changes in ventilation air change requirements in each classroom, can increase the proportion of latent load and cause humidity to rise. High humidity levels may affect operation and reliability of computer equipment or

building structural materials. In addition, students entering and leaving classrooms result in a variation in latent load for each room, which requires maximum part load dehumidification control.

Restaurants and Fast Food Chains

As in schools, high variable occupancy can result in humidity issues. In addition, kitchen areas of restaurants have many humidity producing activities, such as dishwashing and cooking.

Health Clubs

Shower areas and human perspiration cause uncomfortable space conditions with high humidity. In addition to human discomfort, these conditions can propagate the growth of mold and mildew.

Convenience Stores and Supermarkets

High humidity levels can cause inefficient operation of refrigeration and freezer systems.

Museums and Libraries

These applications require tighter control at part load conditions, since high humidity levels can cause substantial damage to priceless books and artifacts.

Humid Climates

In climates along the coast, when the actual temperature drops, the outdoor wet-bulb temperature may remain the same or increase. This results in a need to provide more latent capacity to prevent humidity levels from increasing in the space.

SYSTEM OVERVIEW

Modes of Operation

The design of the Humidi-MiZer adaptive dehumidification system allows for two humidity control modes of operation of the rooftop unit utilizing a common subcooling/reheat dehumidification coil located downstream (with respect to airflow) of the standard evaporator coil. This unique and innovative design provides the capability for the rooftop unit to operate in both a subcooling mode and a hot gas reheat mode for maximum system flexibility. The Humidi-MiZer system is factory installed and will operate whenever there is a dehumidification requirement present. The Humidi-MiZer adaptive dehumidification system is initiated based on input from a factory-installed return air humidity sensor to the large rooftop unit controller. Additionally, the unit controller may receive an input from a space humidity sensor, a discrete input from a mechanical humidistat, or input from a third-party controller.

Conventional Cooling Mode

Conventional operation of the rooftop unit allows the unit to cycle up to six compressors to maintain comfort conditions with enhanced comfort control capability offered by the optional digital compressor equipped unit. This mode is the conventional DX cooling method used on Carrier's standard rooftop units and provides equivalent capacity to a cooling only unit without the Humid-MiZer adaptive dehumidification system, such as at design ARI cooling conditions of 95 F ambient temperature and 80 F/67 F db/wb entering air conditions. The SHR (sensible heat ratio) for equipment at these conditions is typically 0.7 or higher. The Humid-MiZer system operation at high ambient temperatures remains identical to the standard unit.

Subcooling Mode

This mode will be engaged to satisfy part load type conditions when there is a space call for cooling and dehumidification. Although the temperature may have dropped and decreased the sensible load in the space, the outdoor and/or space humidity levels may have risen. This situation might occur when the outside air is 85 F with 70 to 80% relative humidity (RH). Desired SHR for equipment under these conditions is typically 0.4 to 0.7. Carrier's applied rooftop unit with Humidi-MiZer adaptive dehumidification system will increase subcooling entering the evaporator and cycle on enough compressors to meet the latent load requirement, while simultaneously adjusting refrigerant flow to the Humidi-MiZer system coil to reheat the air to the required supply air set point for cooling. This will allow the unit to provide variable SHR to meet space requirements. Conversely, a standard unit might overcool the space or stage down compressors to meet a set point, sacrificing latent capacity control. The Humidi-MiZer system will initiate subcooling mode when the space temperature and humidity are both above the temperature and

humidity set points, and attempt to meet both requirements. Once the humidity requirement is met, the unit can continue to operate in normal cooling mode to meet any remaining sensible capacity load. Alternatively, if the sensible load is met and humidity levels remain high the unit can switch to Hot Gas Reheat mode to provide neutral, dehumidified air.

Reheat Mode

This mode is used when dehumidification is required without a need for cooling, such as when the outside air is at a neutral temperature (70 to 75 F) but high humidity exists. This situation requires the equipment to operate at a low SHR of 0.0 to 0.2. With no cooling requirement and a call for dehumidification, the applied rooftop unit with Humidi-MiZer adaptive dehumidification system will cycle on enough compressors to meet the latent load requirement while simultaneously adjusting refrigerant flow to the Humidi-MiZer coil to reheat the air to the desired neutral air set point. The controls on the rooftop unit with Humid-MiZer adaptive dehumidification system allow for the discharge air to be reheated to either the return-air temperature minus a configurable offset or to a configurable Reheat set point (default 70 F). The hot gas reheat mode will be initiated when only the humidity is above the humidity set point, without a demand for cooling.

System Control

The essential difference between the Subcooling mode and the Reheat mode is in the supply air set point. In Subcooling mode, the supply air set point is the temperature required to provide cooling to the space. In Reheat mode, the supply air set point is the temperature required to provide neutral air to the space. In both cases, the unit will decrease the evaporator air discharge temperature to meet the latent

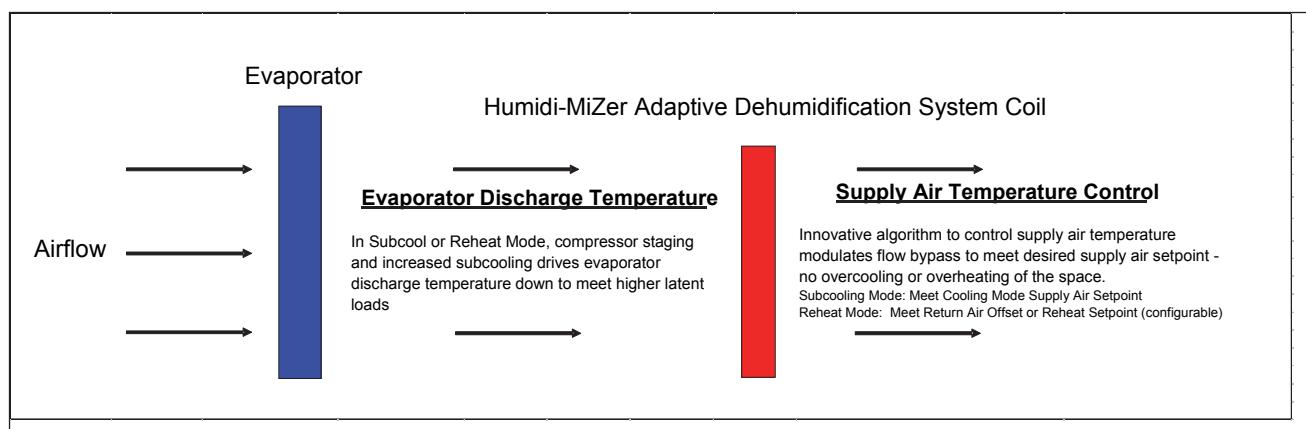


Fig. 1. Control of Evaporator Discharge Temperature and Supply Air Temperature

load demand and reheat the air to the required cooling or reheat set point (i.e., 50, 60, 70 F, etc). See Figure 1.

The applied rooftop unit with the Humidi-MiZer® adaptive dehumidification system uses an innovative refrigerant flow modulation design that provides accurate control of the leaving-air temperature as the evaporator discharge temperature is decreased to meet the latent load demand. As the refrigerant leaves the compressor, the modulating valves vary the amount of refrigerant that enters and/or bypasses the condenser coil. This refrigerant is mixed with the refrigerant flow exiting the condenser in the liquid line. By varying the quality of the mixture in the liquid line, the capacity of the reheat coil can be adjusted to control the resulting supply-air temperature. This creates the flexibility to supply any combination of hot discharge gas, adjustable quality two-phase mixture, or subcooled liquid through the Humidi-MiZer system reheat coil. As the hot refrigerant liquid, gas or two-phase mixture passes through the Humidi-MiZer

system coil, it is exposed to the cold supply airflow coming from the evaporator coil. The refrigerant is subcooled in the Humidi-MiZer system coil to a temperature approaching the evaporator leaving air temperature. The liquid refrigerant then enters a thermostatic expansion valve (TXV) where the refrigerant pressure is decreased. The refrigerant enters the TXV and evaporator coil at a temperature lower than in standard cooling operation as its temperature is no longer limited by the outdoor-air temperature. This lower temperature increases the latent capacity of the evaporator. The refrigerant passes through the evaporator and is turned into a superheated vapor. The air passing over the evaporator coil will become colder than during normal operation. However, as this same air passes over the Humidi-MiZer system reheat coil, it will be warmed to meet the supply air set point temperature requirement. See Figure 2.

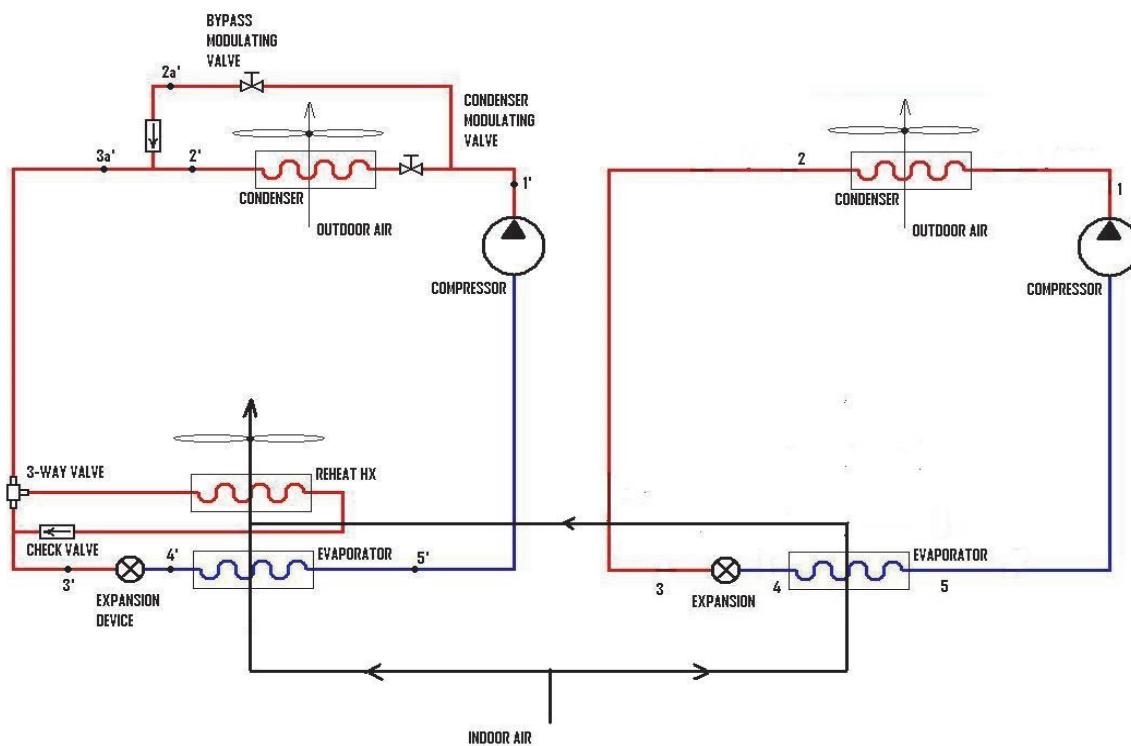


Fig. 2. Humidi-MiZer® Adaptive Dehumidification System

System Performance

Rooftop performance for normal cooling, subcooling and reheat modes are illustrated in tables provided in the applied rooftop Product Data literature. For reheat performance, the ambient outdoor air and return air temperature ranges are different from the ranges listed for normal design cooling rooftop operation. The change in temperature ranges provides appropriate performance data for those conditions when the rooftop unit would most likely respond to provide latent capacity removal from the conditioned space. All performance data are provided in terms of gross capacities. Combined, the subcooling and reheat tables provide the endpoints of performance potential for each unit. In reality, the Carrier applied rooftop

unit equipped with the Humidi-MiZer® adaptive dehumidification system will modulate refrigerant bypass flow to ensure that it meets the supply air set point while maintaining low evaporator temperatures for maximum moisture removal. This means that the unit sensible capacity varies between the two tables, depending on the load in the space. (See Figure 3 below.) Note that latent capacity stays fairly constant between Subcooling mode and Reheat mode, while sensible capacity varies almost infinitely between the two endpoints of the table. This clearly demonstrates how accurate space temperature and humidity control can be maintained through the applied rooftop units innovative modulating refrigerant flow valves.

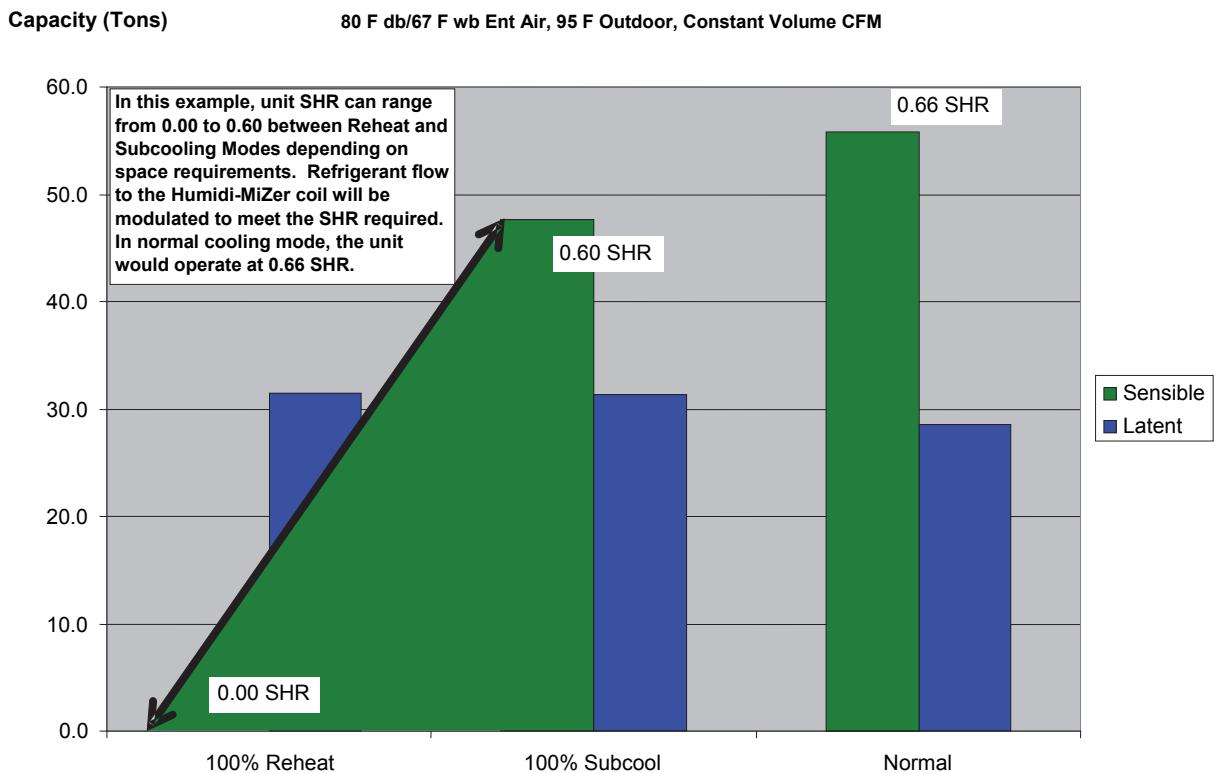


Fig. 3. Variable Sensible Heat Ratio (SHR) Example

SUMMARY COMPARISON

The chart below compares Carrier's Humidi-MiZer® adaptive dehumidification system to the hot gas reheat concept employed by some competitors. The performance of the applied rooftop units equipped

with the Humidi-MiZer adaptive dehumidification system option provides unprecedented flexibility to meet year-round comfort conditions.

CHARACTERISTIC	COMPETITOR HOT GAS REHEAT CONCEPT	HUMID-MIZER® ADAPTIVE DEHUMIDIFICATION SYSTEM USING TWO-PHASE MIXTURE REHEAT CONCEPT	HUMIDI-MIZER SYSTEM ADVANTAGE
Modes of operation	<ul style="list-style-type: none"> Two modes of operation: <ul style="list-style-type: none"> - Conventional cooling - Dehumidification (hot gas) 	<ul style="list-style-type: none"> At least three modes of operation: <ul style="list-style-type: none"> - Conventional cooling - Dehumidification (<u>hot gas and two-phase mixture capability</u>) - Cooling and enhanced dehumidification (warm liquid) 	
Variable performance	<ul style="list-style-type: none"> System performance at the design point cannot be varied without altering the components Overheating and overcooling may occur at off design performance 	<ul style="list-style-type: none"> System performance at the design point is adjusted by accurate control of refrigerant bypass around and into the condenser. Both cooling and reheat supply air set points can be met at varying entering and outdoor air conditions. <ul style="list-style-type: none"> - Variable sensible heat ratio 	
Charge migration	<ul style="list-style-type: none"> Design is less stable due to charge migration System operation is more sensitive to charge migration 	<ul style="list-style-type: none"> Design is stable, minimal charge migration. System operation is not altered 	
Latent capacity maximization	<ul style="list-style-type: none"> Latent performance of the reheat cycle slightly exceeds latent capacity of the conventional system (ambient temperature limitation is restrictive) 	<ul style="list-style-type: none"> Latent performance of the dehumidification cycle can significantly exceed latent capacity of the conventional system (ambient temperature has insignificant impact on latent capacity) 	
Operation at higher ambient temperatures	<ul style="list-style-type: none"> May overheat the space at higher ambient temperatures Switching to the conventional cooling mode of operation at high ambient temperatures reduces dehumidification capability of the system 	<ul style="list-style-type: none"> Switching to the enhanced dehumidification mode of operation at high ambient temperatures enhances dehumidification capability of the system Unique modulating valve system allows unit to adjust the quality of the refrigerant entering the Humidi-MiZer system coil; unit will not overheat the space as outdoor temperatures rise 	
Ambient temperature	<ul style="list-style-type: none"> System performance degrades with the ambient temperature elevation: <ul style="list-style-type: none"> - Sensible capacity (\downarrow) - Latent capacity (\downarrow) 	<ul style="list-style-type: none"> System performance improves at high ambient temperatures <ul style="list-style-type: none"> - Sensible capacity is reduced at a lower rate (relative to the hot gas reheat concept) - Latent capacity is augmented 	



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