ROOFTOP UNITS

Energence®

Enhanced Humiditrol® Dehumidification System

APPLICATION AND DESIGN GUIDELINES

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This document provides an overview of hot gas reheat, liquid subcool reheat, a combination of hot gas and subcool reheat, Lennox' Humiditrol dehumidification system, and the advantages and disadvantages of each system.

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Technological Approaches to Varying Latent and Sensible Loads:

Most applications require the removal of both sensible (temperature) and latent (humidity) heat. Air conditioning systems can meet this demand by operating in the normal cooling mode, where the system provides both cooling and dehumidification. When the application only requires the removal of humidity, many air conditioning system use a combination of the normal cooling mode plus some type of reheat system. A reheat system allows the unit to either partially or fully heat the dehumidified/cooled air before entering the occupied space.

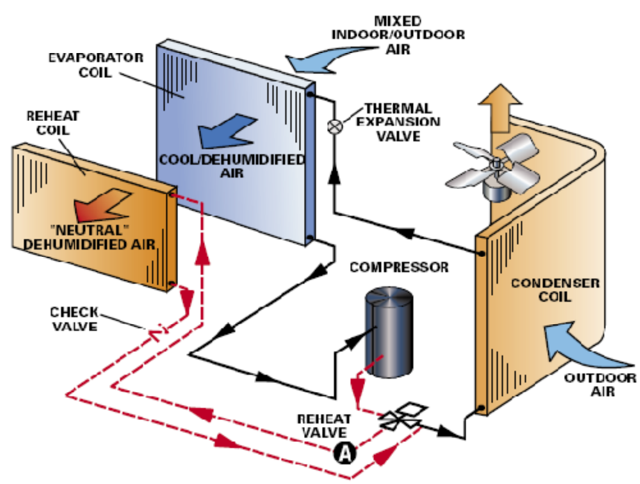
Several approaches are being used by air conditioning manufactures to address this varying latent and sensible capacity load in buildings. This includes:

1. Refrigerant liquid subcooling reheat
2. Refrigerant hot-gas reheat
3. Combination of refrigerant hot-gas reheat and refrigerant liquid subcooling reheat

Hot-Gas Reheat System Overview:

For typical hot-gas reheat systems, the refrigerant hot-gas coming out of the compressor is routed to a coil that is downstream of the evaporator coil. This uses some of the heat that was normally rejected to the outside air in the condenser coil to reheat the air that passes through the evaporator coil. Most refrigerant hot-gas reheat systems like this are designed to raise the temperature to close to what the mixed air temperature is entering the evaporator coil. This in effect allows full dehumidification to take place without adding any sensible heat or a very small amount of sensible heat. This works very well when there is a very low sensible load and a significant latent load in a building. When the sensible increases, then the system switches back and forth between the normal mode and the reheat mode.

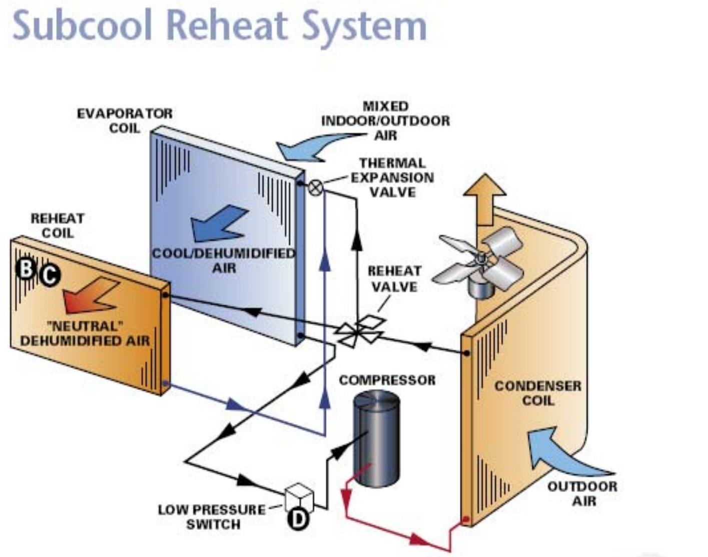
Lennox' Humiditrol System



A Hot gas (200F or more) exiting compressor increases ability of reheat coil to reheat air up to neutral conditions

Liquid Subcooling Reheat System Overview:

In subcool reheat systems, the refrigerant, in the form of a hot gas exits the compressor and first passes through the condenser coil before moving through the reheat coil. The condenser coil cools the hot gas refrigerant and changes the refrigerant from a gas into a liquid. Because the refrigerant temperature is fairly low, the reheat coil can only heat the air up a few degrees. This process allows the system to deliver partially cooled and fully dehumidified air to the occupied space. Because the system delivers a smaller cooling load than a standard system, the unit will typically have to operate for a longer period of time to satisfy the same cooling demand. This allows for additional dehumidification to take place and helps control humidity levels within the desired space. While this type of system does help control humidity levels when a cooling demand is present, it will typically not provide enough reheat to the desired temperature when the occupied space only requires humidity removal.



B Condensed liquid requires additional charge in system increasing chances of compressor failures

C Subcooled liquid (~100F) limits reheat coil's ability to warm up air

D Low pressure switch decreases reliability of system

While the subcool reheat system does provide more latent capacity removal than a hot gas reheat system, there are several distinct disadvantages that may prevent the system from effectively controlling and removing humidity. First, the subcool reheat system's ability to remove humidity is limited by the run-time of the system. As mentioned before, when there is no demand for cooling, the system cannot dehumidify. Therefore, in a situation where the occupied space is calling for dehumidification but the temperature remains satisfied, a subcool system will typically not activate and start removing moisture until a temperature demand has been sensed. In addition, because subcool reheat systems lower the refrigerant liquid temperature, and subsequently the evaporator coil temperature, there is an increased chance of ice build up on the evaporator coil during mild conditions. In the event of ice build up, the system must stop operation to de-ice the coil, limiting dehumidification capabilities. It is during these mild conditions that dehumidification is often most needed, and stopping operation to de-ice the evaporator coil can prevent adequate humidity control and dehumidification from taking place. Lastly, subcooling reheat systems also require more refrigerant charge than hot-gas reheat systems (due to a reduction in volume from gas to liquid in the subcooling/reheat coil), which increases the chances of having compressor failures.

Combination of Hot-Gas and Liquid Subcooling Reheat Overview:

Just like a hot-gas reheat system, the combination subcool and hot gas reheat system can also provide a range of S/T ratios through a variety of dehumidification and cooling operation combinations. In single or multiple circuit units, each circuit can operate in either a subcool or hot gas reheat mode. Typically, the combination system does not exceed two circuits, as cost, space limitation, and complexity of additional loops makes it cost prohibitive and impractical to implement this on a three or four-circuit system.

For a single circuit combination system, it will cycle between cooling, subcool reheat, and hot-gas reheat for cooling and dehumidification demands. If a cooling demand is present, the system will typically operate in cooling mode to satisfy the demand in the shortest time possible. In cases where there is a small cooling demand, but high latent demand, the system will operate in a subcool reheat mode, where the cooling demand will be quickly satisfied, and the system will have to switch to the hot-gas reheat mode to continue dehumidification. Note that the hot-gas reheat system can accomplish the same goals, without the intermediate step and aforementioned disadvantages of the subcool reheat system, by satisfying the temperature demand quicker (while dehumidifying), then switching over to the hot-gas reheat mode to continue to dehumidify once temperature demands are met.

For two-circuit combination systems, the system can operate in up to nine different modes through staging (i.e. two circuits in subcool reheat, two circuits in hot gas reheat, etc.). However, a typical system only operates in five modes or less to limit complexity in control logic. More importantly, not all modes are necessary from a practical standpoint. For example, a mode where circuit one is in cooling, and circuit two is in subcool reheat will rarely be used since the output temperature will be much closer to the mode when both circuits are running in full cool rendering it impractical as a dehumidification mode. As mentioned before, it is important to provide a range of S/T ratios to independently control temperature and humidity. Through staging, both the hot-gas reheat system and the combination systems can provide roughly the same range of S/T ratios, but the hot-gas reheat system can do so without the additional complexity and decreased reliability of subcooling systems. Introducing the subcooling system with the hot-gas reheat system provides little marginal value when weighing the costs and limited use of the subcooling system.

HUMIDITROL DEHUMIDIFICATION SYSTEM OVERVIEW:

The Humiditrol dehumidification system allows a Lennox constant air volume packaged unit to provide the following benefits:

- Independent control of both the temperature and humidity levels of the enclosed space.
- Increased dehumidification capability without overcooling the enclosed space.
- Reduced energy consumption by using hot gas reheat from the active compressors (compared to auxiliary reheat systems).

For additional information, sequence of operation and performance data, please reference the Energence Packaged Unit Engineering Handbook bulletins.

Enhanced Humiditrol Dehumidification System for Energence 3 to 5 Ton RTUs

Since there are several design approaches to keep the conditioned space at satisfactory relative humidity levels in applications where there can be large latent loads and small sensible loads, the challenge is how to do this using the least amount of energy. Lennox’s response to this challenge is the enhanced Humiditrol dehumidification system on the 3 to 5 ton models. The enhanced system can satisfy a variable latent and sensible load application more efficiently than any of the aforementioned systems. There are five primary reasons for this. They are:

1) The enhanced Humiditrol dehumidification system sends all of the hot-gas to the reheat coil before going through the condenser coil, using the entire heat transfer surface in the condensing part of the system, which results in the lowest discharge pressure in the reheat mode. This also lowers the evaporator temperature, which removes more moisture from the air in the reheat mode.

2) The enhanced Humiditrol dehumidification system is also designed to lower the supply airflow to further increase latent capacity and to reduce the overall power needed. Slowing down the airflow reduces the evaporator temperature, resulting in an increased latent capacity. Reducing the blower speed lowers energy usage, with the blower accounting for approximately 10% of the total system watts.

3) The Energence rooftop unit also uses a variable speed motor for the outdoor fan in its high efficiency models, which operates on low speed in the dehumidification mode. This reduces the power consumption of the outdoor fan by 30-40%.

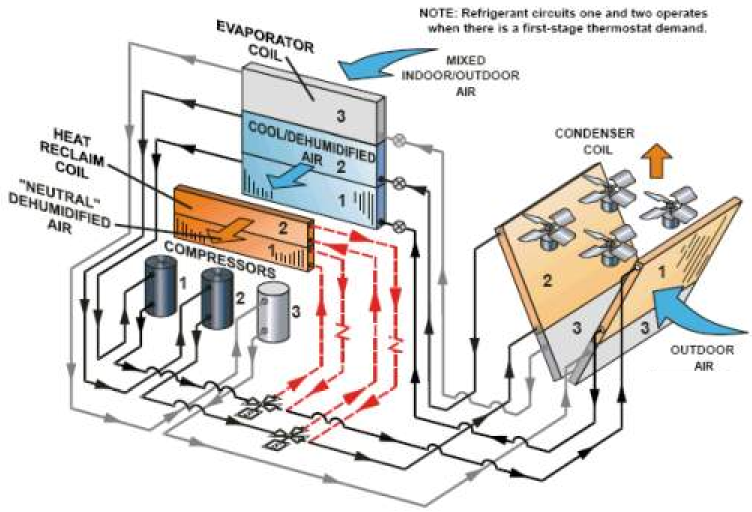
4) The Energence rooftop unit is designed to provide a little bit of sensible cooling capacity when in the hot-gas reheat mode, since most applications still have some internal sensible load from lights, machines and/or people. This allows the Energence rooftop unit to operate for long periods of time when there is a large latent load without cycling between the hot-gas reheat mode and the normal operating mode. This keeps the indoor humidity levels from fluctuating very much throughout the operating period.

5) The Energence rooftop unit also has a two-step scroll compressor that operates on low speed during part load conditions. Therefore, when there is a sensible demand, it operates in the low speed compressor mode. The system efficiency is significantly higher in this mode. Even though the latent capacity is lower, it is still satisfies the latent demand in conjunction with the hot-gas reheat mode, and uses less power to do it.

When compared to any other dehumidification system, the Energence is the most efficient refrigerant hot-gas reheat system on the market at meeting a variable latent to sensible cooling load. This means that it can remove the necessary amount of moisture from the air entering the evaporator coil to maintain comfort conditions, and do it using less energy. The following table shows how the performance of the enhanced Humiditrol dehumidification system compares to the performance of a combination hot-gas and liquid subcooling system at a part load condition where the latent load is higher than the sensible load.

PLEASE SEE APPENDIX A FOR COMPARATIVE DEHUMIDIFICATION PERFORMANCE

The Humiditrol Hot Gas Reheat System 7.5 Tons and Above



Lennox' Humiditrol hot gas reheat system (7.5 tons and above) features separate refrigeration circuits and an intelligent control system which allows the system to independently control both temperature and humidity demands. The Humiditrol dehumidification system uses a combination of two, three or four refrigeration circuits (depending on unit tonnage size) to optimize the sensible to latent (S/T) heat removal to meet a variety of application demands. This provides superior comfort control and great indoor air quality.

Using a system with three separate refrigeration circuits as an example, if the occupied space needs full dehumidification and no cooling, the system will respond by activating two circuits with reheat coils. The unit will dehumidify and cool all the air entering the unit with the evaporator coils and then warm up the conditioned air using the reheat coils. This will allow the unit to return fully dehumidified air back to the occupied space at a neutral air temperature.

If the occupied space needs full dehumidification but only limited cooling, the system will activate the third cooling circuit. With all three evaporator coils active and two reheat coils active, full dehumidification will continue to take place and allow the unit to return fully dehumidified air back to the occupied space while still providing a limited amount of cooling.

Finally, if the occupied space needs dehumidification and cooling, the system will deactivate both reheat coils. The system will operate in normal cooling mode, returning fully dehumidified air back to the space while providing the maximum amount of cooling possible. The table below shows the different S/T ratios and latent capacities Lennox' Energence 15-ton high efficiency rooftop unit can achieve in order to better match demand requirements. All data are shown at the following operating point: Condenser Air Inlet Temperature = 75º F DB, Evaporator Air Inlet Conditions: 6000 RPM, 67º F WB, 75º DB.

Stage	S/T Ratio	Total Cooling Capacity (kBtuh)	Latent Capacity (kBtuh)
Two Compressors in Cooling Mode	.60	130.7	58.8
Three Compressors in Cooling Mode	.60	189.1	75.6
Two Compressors in Reheat Mode, One Compressor in Cooling Mode	.48	161.9	84.2
Two Compressors in Reheat Mode	.37	94.0	59.2

Table 1: Lennox Energence 15-ton High Efficiency Rooftop with Humiditrol

Controlling the cooling and dehumidification operation with this type of equipment configuration has several advantages. First, this set up requires a limited number of additional components for operation. The only additional parts are a reheat valve, reheat coil and refrigerant lines to and from the reheat coil. This simplicity helps limit possible mechanical system failures and helps make trouble shooting or service and maintenance quick and easy.

It is possible to substitute the subcooling reheat system in place of the hot gas reheat system to attain variations in S/T ratios. However, subcooling reheat systems will not attain lower S/T ratios like the hot gas reheat system, thereby reducing its ability to independently control temperature and humidity.

SUMMARY

The wide variety of load and sensible cooling loads in many buildings requires air conditioning systems with a hot-gas reheat option to keep the conditioned space at comfortable humidity levels throughout the air conditioning season. Most air conditioning manufacturers now offer some type of hot-gas reheat option in their air conditioning units. The challenge now is for air conditioning manufacturers to do this using the least amount of energy. Lennox has done this with the enhanced Humiditrol dehumidification system on the Energence 3 to 5 ton models that use variable speed motors to significantly reduce the system power in the dehumidification mode. This system is more efficient than any other hot-gas reheat system, including systems that are a combination of hot-gas reheat and liquid subcooling reheat.

APPENDIX A

Comparative Dehumidification Performance at 75°F Outdoor, 75°F DB / 65°F WB Indoor, 1750 CFM for the Energence Enhanced Humiditrol Dehumidification System vs. a Combination Hot-Gas and Liquid Subcooling Reheat System (5 ton system)

					5	6	7	8
System/Operating Mode	**Total Capacity**	**Sensible Capacity**	**Latent Capacity**	**Power**	**Min. Operating in this mode**	**Part Load Sensible Capacity**	**Part Load Latent Capacity**	**Part Load Power**
Part Load in Space	- - -	- - -	- - -	- - -	- - -	8,000	17,500	- - -
Combination Hot-Gas and Liquid Subcooling Reheat System								
Normal Cooling	64,800	40,241	24,559	4280	7.0	4695	2865	499
Subcooling Reheat	64,800	36,041	28,759	4340	7.0	4205	3355	506
Hot-Gas Reheat	19,890	-1390	21,280	4290	32.0	-741	11,349	2288
Total Performance	- - -	- - -	- - -	- - -	46.0	8158	17,570	3294
Energence With Enhanced Humiditrol Dehumidification System								
Low Speed	48,100	32,710	15,390	2605	2.0	1090	513	87
Hot-Gas Reheat	36,450	10,570	25,880	3865	40.0	7047	17,253	2577
Total Performance	- - -	- - -	- - -	- - -	42.0	8137	17,766	2664
						Power Savings		**19.1%**

EXAMPLE

Space Conditions:

Sensible load = 8,000 Btu, Latent load = 17,500 Btu, Relative Humidity = 90%

The combination hot-gas reheat and liquid subcooling reheat system can operate in the three modes shown in the table. The table shows the total, sensible and latent capacity, and the power consumed in each of these modes in the first four columns. The Energence can operate in the two modes shown in table. The total, sensible and latent capacity, and power consumed in each of these modes are also shown.

Column 5 shows how many minutes each of the modes would operate in a hour to meet the sensible and latent loads. Columns 6 and 7 show the sensible and latent capacity delivered by each of these modes for the time it operates. Column 8 is the power consumed during each of the operating modes. The total performance rows show the total performance of each of the systems when adding the performance of its operating modes. For the same sensible and latent capacity delivered, the Energence system does it for 19% less energy than the combination system.

This same comparison can be made at a number of different loads and outdoor conditions, and the results will change. But the Energence system consistently outperforms the combination hot-gas and liquid subcooling reheat system by using 10-20% less power to deliver the same sensible and latent capacity to the space. This comparison can also be made against other hot-gas reheat systems, and the results are close to the same.