

# A Thermosyphon Run Around Heat Pipe Can Solve Mold Causing Problems

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## Background

A commercial air conditioning system, since its earliest creation by Doctor Carrier, has been capable of both cooling air as well as lowering its water content. The cooling ability of an air conditioning system is well understood. The fact that the air conditioning process often results in moisture removal as well as temperature reduction is not so well understood. This is particularly true for both the public and the regulatory officials that define equipment performance. This lack of understanding has resulted in serious health problems that are only now showing up in the news media, litigation and more recently insurance companies that are either limiting or eliminating their coverage resulting from mold damage.

## Relationship of Relative Humidity and Mold Growth

While there are many factors that can cause a sick or unhealthy building, when the relative humidity (amount of moisture in the air) in the air is maintained in the range of 40 –60 % health related problems are minimized. This is illustrated in figure 1 which shows the ever increasing human health effect due to fungi (mold), bacteria and viruses as relative humidity increases beyond the Optimum Zone.

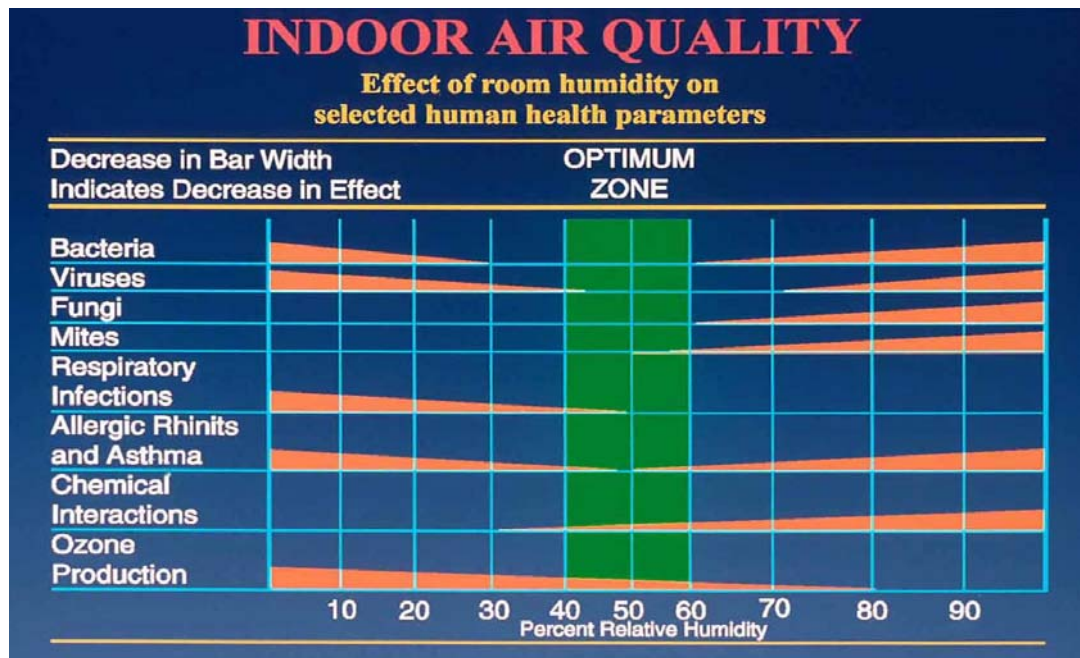


Figure 1. Optimum relative humidity range for minimizing adverse health effects (adapted from "Indirect Health Effects of Relative Humidity in Indoor Environments" by Arundel, Sterling, Biggin, and Sterling)

Many of our mold and mildew problems can be traced back to the energy crisis of the 1970's. Our buildings were made tighter to save energy. Sun load was reduced with better insulation and energy saving windows. More energy efficient lighting that caused less sensible heat load was installed. New codes were developed. One such code defined Seasonal Energy Efficiency Ratio (SEER) as the amount of Cooling BTUH generated divided by the BTUH of Energy consumed to generate that cooling BTUH. The higher the ratio the better the equipment energy performance.

*Moisture Load In Air*

It takes 21,600 BTUH to cool 1000 CFM of air at 95/50% RH to 75/95% RH  
(1.08x CFM x delta T)

It takes 65,621 BTUH to cool 1000 CFM of air at 75/95% RH to 55/95% RH.

Of this 43,180 BTUH is Latent Load (.68 x CFM x delta g)

**Lowering Humidity is twice as hard as Cooling!**

**Figure 2. Calculating energy required removing Latent and Sensible loads**

Since it requires 2 times as much energy to condense moisture from air as it does to lower temperature (see calculations below), the performance relationship of many air conditioners and heat pumps being manufactured were changed. The cooling ability (Sensible Capacity) was increased and the moisture removal ability (Latent Capacity) reduced to achieve a higher SEER rating.

Unfortunately, reducing the latent capability of air conditioners further magnified the effect of building envelope load changes due to the better insulation, energy saving lighting and windows and tighter construction. The improved envelope had indeed reduced the sensible load but not the latent load at the very time the air conditioning and heat pump manufacturers were reducing the latent capacity of the equipment to achieve higher SEER ratings. The net result was many fine energy efficient air conditioning systems are less able to remove moisture than the old inefficient equipment they replaced. The net effect is people are complaining about feeling cool and clammy and are concerned about mold and mildew and want their high humidity problem corrected.

### **Moisture Load**

Moisture load is caused by such things as: bathing & showering, cleaning of windows, mopping of floors, humid outside air, drying clothing, fish tanks, cooking, plants, people breathing, any process that promotes the evaporation of water.

To maintain a healthy building indoor environment the humidity level must be maintained in the optimum zone of 40-60% Relative Humidity. This can be done in an energy efficient manner by incorporating a Thermosyphon Run Around Heat Pipe Heat Exchanger like the one described below into the air handler portion of an air conditioning system. This technique changes the performance heat ratio between temperature reduction and moisture

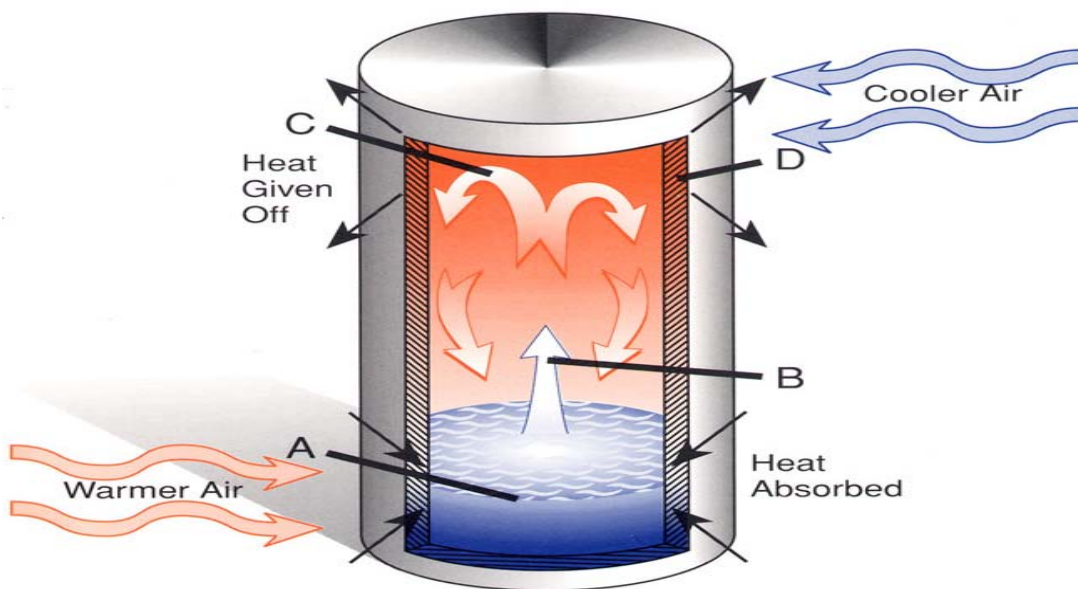
removal without changing the total capacity of the system. The result is a more forgiving air conditioning system. A system that is now better able to overcome moisture loads including infiltration as well as the high latent load often associated with part load conditions.

### **A Thermosyphon Run Around Heat Pipe Heat Exchanger**

During the past several years a series of humidity control solutions and energy recovery solutions have been applied to several high profile heating, refrigeration and air conditioning installations. In these cases the building owner was interested in providing a simple, reliable, energy efficient long-term solution to a requirement for a healthy indoor air environment.

Many of these solutions have utilized a Thermosyphon Run Around Heat Pipe Heat Exchanger to transfer heat from the entering air or return air of an air conditioning unit to the supply air leaving an air conditioning system.

While there are many different forms of heat pipe heat exchangers, most have been developed to optimally meet a particular application. All employ the same basic principle. In its simplest form a heat pipe is a sealed tube which has been evacuated, charged with a precise amount of refrigerant and sealed. The actual function of a heat pipe is described in the figure below.



**Figure 3. Basic Heat Pipe Operation**

The refrigerant (A)-Absorbs heat from a heat source. In the above figure, the heat source is the warm air shown passing over it. The refrigerant changes state and rises as vapor (B), At point (C), the vapor gives us heat to a heat sink, the cool air, where it condenses back to a liquid (D). The condensed refrigerant is returned by gravity to complete the process. This vaporizing and condensing process continues as long as there is a temperature differential between the two ends of the heat pipe.

Shown below is a schematic of how a heat pipe is used in an air conditioning system to passively reduce the energy requirement while providing free reheat for dehumidification.

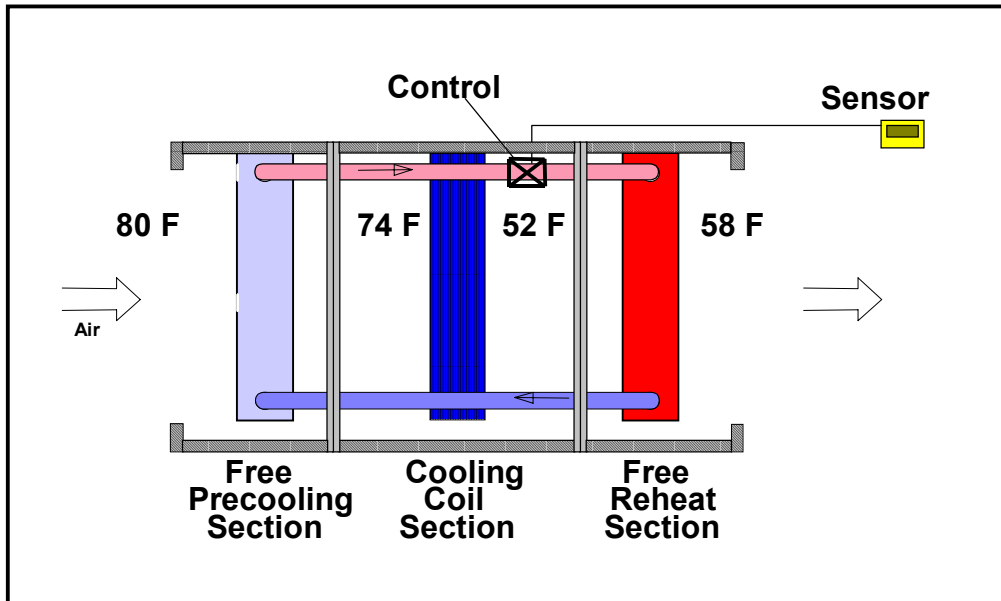


Figure 4. Diagram of Basic Thermosyphon Run Around Heat Pipe

### Other Benefits from Controlling Relative Humidity

This reduction in humidity level has an additional benefit when we consider the comfort factor. By lowering the relative humidity people occupying an indoor air environment are comfortable at a higher room temperature.

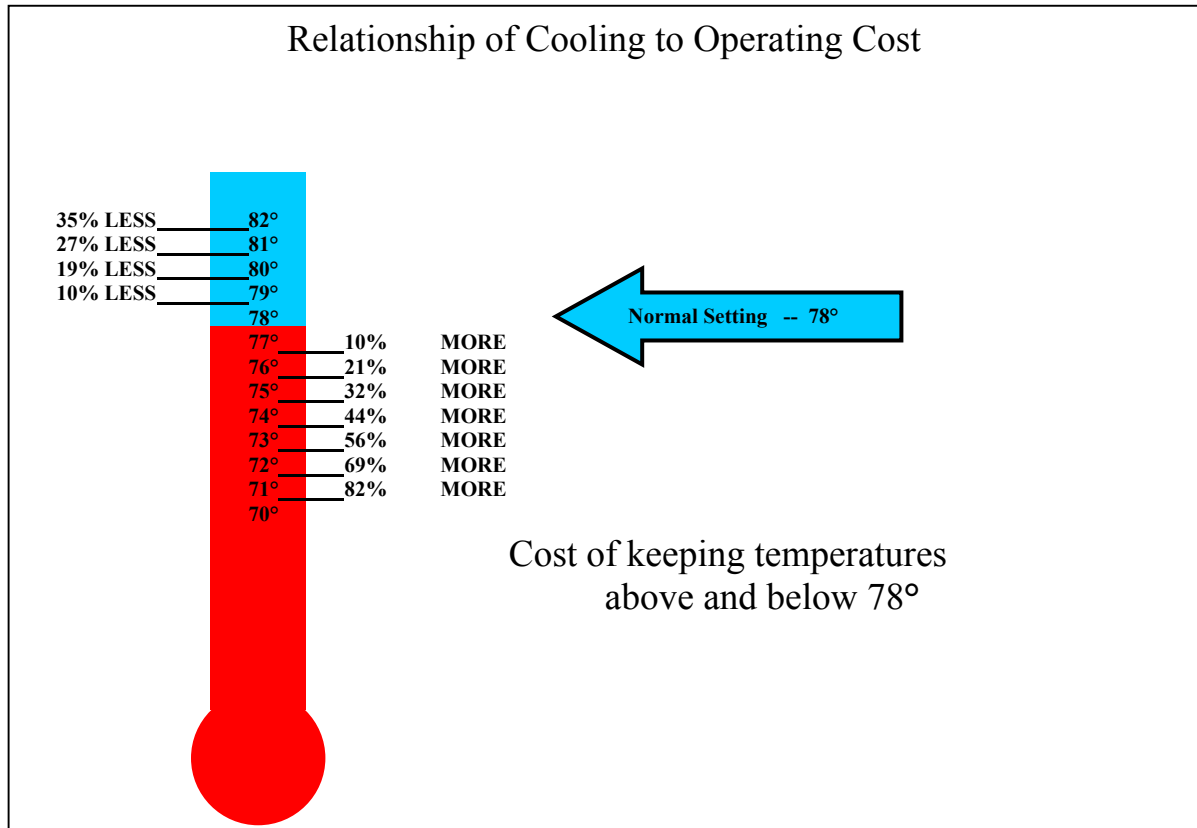
We see this relationship of humidity and temperature in the comfort chart shown below. From this chart we can see that 76F at 90% RH feels like 82F. However 76F at 50% RH feels like a comfortable 70F.

		RELATIVE HUMIDITY									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
T E M P E R A T U R E	76°		60°	63°	67°	70°	73°	76°	79°	82°	85°
	78°		63°	67°	70°	74°	76°	78°	82°	85°	89°
	80°	62°	66°	70°	73°	77°	80°	82°	88°	90°	93°
	82°	63°	68°	72°	76°	80°	82°	88°	90°	93°	97°
	84°	66°	71°	76°	79°	83°	86°	90°	94°	98°	103°
	86°	68°	73°	78°	82°	86°	90°	94°	98°	103°	
	88°	70°	76°	81°	85°	89°	93°	98°	102°	108°	
	90°	73°	78°	84°	88°	93°	97°	102°	108°		
	92°	75°	82°	87°	91°	96°	101°	108°	112°		
	94°	77°	84°	90°	95°	100°	107°	111°			
F A H R E N H E I T	96°	79°	87°	93°	98°	103°	110°	118°			
	98°	82°	90°	98°	101°	107°	114°				
	100°	85°	92°	99°	105°	111°	118°				
	102°	87°	95°	102°	108°	115°	123°				
	104°	90°	98°	106°	112°	120°					

Figure 5. Comfort Chart

## Energy Savings

The energy saving from maintaining comfort at a higher temperature is readily apparent from the following graphic developed by the South Carolina Electric and Gas Company.



**Figure 6. Relationship of Cooling to Operating Cost**

### Summary

There are many High SEER rated units on the market today. At ARI standard conditions they consume less energy per BTU of cooling than their less efficient predecessors. However their specific heat ratio (amount of sensible cooling/ total cooling) is often much higher than the older less efficient models they replaced. This results in the cooling load (thermostat setting) being satisfied before the moisture (latent) load is satisfied.

Modern buildings today employ energy saving techniques to reduce sensible load such as better insulation and more efficient lighting so that the moisture (latent) load has now become a larger portion of the total cooling load. This is particularly true at part load conditions.

One very attractive corrective action is to incorporate a Controllable Thermosyphon Run Around Heat Pipe into the air conditioning system to change the specific heat ratio while providing free reheat without the use of external energy. The Run Around Thermosyphon when properly placed in the air stream will remove some sensible load from the air entering the cooling coil and transfer that energy to function as reheat to lower the relative humidity of the air immediately leaving the cooling coil. The effect of Relative Humidity Room Conditions on selected human health parameters is reflected in figure 1 above. It defines the

Optimum Zone as 40-60 % Relative Humidity. This chart (adopted from ASHRAE Chapter 20) shows that mold growth increase proportionately as the Relative Humidity is increased above the Optimum Zone.

Use of the Thermosyphon Run Around Heat Pipe is an energy efficient way of satisfying concern for avoiding mold problems. When integrated into an air conditioning system, it becomes more forgiving and better able to cope with the higher proportion of Latent Load found in modern buildings. Lowering the relative humidity entering the duct to 70% is cited in paragraph 5.11 of ASHRAE standard 62-2001 "Ventilation for Acceptable Indoor Air Quality". If the relative humidity in occupied spaces and low velocity ducts and plenums exceeds 70%, fungal contamination (for example, mold, mildew, etc) can occur.

### **References:**

- ANSI/ASHRAE Standard 62-2001: paragraphs 5.10 and 5.11
- Arundel, A.V., et al, "Indirect Health Effects of Relative Humidity in Indoor Environments", Environmental Health Perspectives, Vol. 65, pp 351-361, 1986
- Mr. Somchai Paarporn, P.E., ASHRAE Journal, June 1999; pages 32-38- Runaround Loop Heat Recovery with Dehumidification System
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- Beckwith, W.R., B.S., CIAQ, Technical paper," Advanced Technology for Economical Dehumidification to Improve Indoor Air Quality", Proceedings from IAQ Conference and Expo, Tampa, Florida, April 29-May 2 1992

### **About the Author:**

**Richard W. Trent** is president of Carolina Heat Pipe, Charleston, S.C. He is a voting member of ASHRAE TC 7.5- Mechanical Dehumidification and Heat Pipes as well as the vice chair of the recently issued ANSI/ASHRAE Standard 151-2002- Practices for Measuring, Testing, Adjusting and Balancing of Shipboard HVAC&R systems. He is also the Vice Chair for Membership Promotion in Region IV and is past president of the Charleston Chapter of ASHRAE.