Tech Byte 2: Precision Versus Comfort Cooling

The Difference Between Precision Cooling Equipment and Comfort Cooling Equipment

A challenge faced by IT and/or facility managers all over the world: A few hundred square feet of room with servers, network and/or telecom gear or any kind of sensitive control equipment. And it needs to be cooled. The electronics manufacturer says that the temperature should be somewhere close to 70 degrees . And the relative humidity, while not extremely critical, can't be less than about 30% (to prevent static electricity buildup) or excessively high to avoid condensation. The first thought is to tap into the existing chiller system that cools the building. Or, if we need cooling capacity when the chiller is shut down for the winter, we can get a plain vanilla rooftop air conditioner just for the computer room. Whoa. Slow down. Step back for a few minutes and take another look. That might not be the cheapest solution, and it sure isn't the best.

People create a moist heat, requiring more latent cooling capacity

There's a big difference between cooling electronics and cooling people. For starters, people add humidity to a room, and electronics don't. So, you have to consider latent cooling (the ability to remove humidity) and sensible cooling (the ability to remove heat). Room air conditioners, residential central air conditioners, and air conditioning systems for office buildings are designed with a sensible cooling ratio of around 0.60 to 0.70. That means that 60-70% of the work a comfort system does will lower the temperature of the air, and 30-40% of the work will remove moisture. That's about right for a room or a building full of people and a moderate amount of in-and-out traffic, but not a good fit for cooling electronics, which do not product moisture.

Precision air conditioning systems like those made by Liebert have a high ratio of sensible-to-total cooling capacity of 0.85 to 0.95. About 85-95% of the work done by a Liebert precision air conditioning system will be devoted to cooling the air, and 5-15% will be devoted to removing humidity.

Electronic equipment puts off a dry heat, requiring more sensible cooling capacity

That means two things when you want to cool a computer room:

- First, you'll have to buy more comfort capacity to do the same job as a precision air conditioning system. The rule of thumb is that it takes three tons of comfort capacity to do the same cooling job as two tons of precision capacity.
- Second, a comfort system will pull the relative humidity down below the acceptable range for a good part of the year. Which means that you'll have to buy a rehumidification system to put moisture back into the air.

With a Liebert precision air conditioning system, you won't have to worry about that. First, it won't pull nearly as much humidity from the air. Second, for the small amount of humidity it does take out of the air, it has a built-in rehumidification feature that restores just enough to maintain the level specified by the computer manufacturer.

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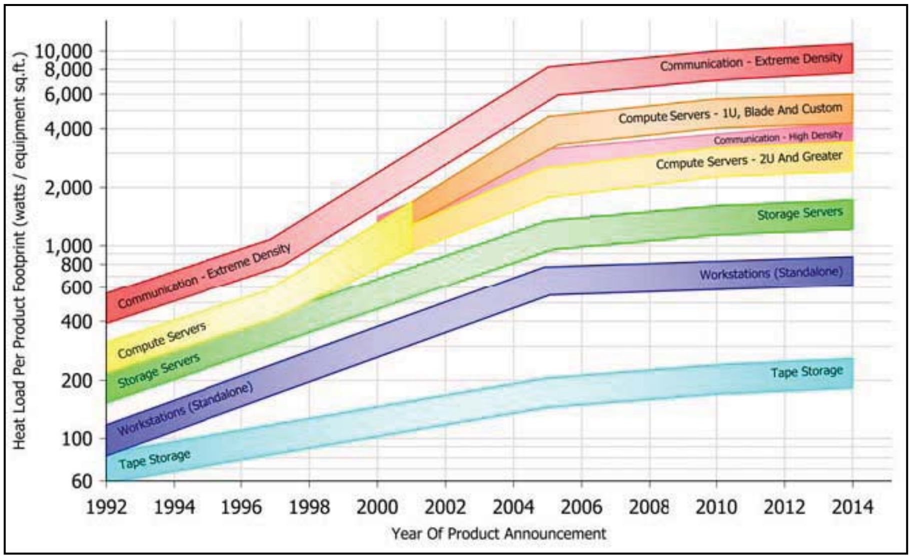
Load Density:
You can put a lot more electronic equipment into a room than you can people. As a result, computer rooms need a lot more cooling capacity per square loot of floor space. The rules of thumb are that you need a ton of comfort air conditioning for every 250-300 sq ft of office space and about a ton of precision air conditioning for every 50-100 sq ft of computer room.   However, it's common for a single rack of computers (in a 2' x 3' footprint) to put off upwards of 3 tons of heat all by itself! See ASHRAE Equipment Power Trends graphic below:



ASHRAE, Datacom Equipment Power Trends and Cooling Applications, 2005. © American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Air Movement:
Another big difference between comfort and precision systems is in the volume of air that must be moved. Typically, a comfort system will move air through its coils at the rate of about 350-400 CFM (cubic feet per minute) per ton of cooling. A precision system will move air at nearly twice that rate – 500-600 CFM – in order to achieve a high sensible cooling ratio, deal with the dense heat load in a computer room, and maintain target temperature and humidity levels. Moving larger volumes of air also contributes to better filtration.

Precision Temperature Control:
Computer manufacturers typically say that you have to maintain close to 70 degrees, or your warranty is void. More important, data integrity and reliability of operation can be affected if the room temperature gets too high or too low. Precision air conditioning systems can do that with ease. Comfort systems just aren't designed to maintain close tolerances. The very best you could expect is ±5 °F.

Precision Humidity Control:
If humidity in a computer room gets too high, you're going to get paper handling problems and face the possibility of condensation in the electronics. If it gets too low, static electricity from the touch of a finger can fry components and alter data. And your magnetic media can suffer oxide shed, increasing the possibility of altered and lost data. A relative humidity target of 45% ±5% is no problem for a Liebert precision air conditioning system. It has the accuracy and precision to meet that target, and it can operate in whatever mode is most appropriate (see chart, next section). A comfort system has only two modes of operation…cooling and off. True, while it's cooling, it's also dehumidifying, but that's incidental. Moreover, it is incapable of adding humidity during the winter season. When you get right down to it, a comfort system offers no control over relative humidity.

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Operating Hours:

A Liebert precision air conditioning system is designed to operate whenever your electronic equipment is operating. For most companies, that means 24 hours per day, 365 days a year. The total is 8,760 hours per year. So, the circulating fan runs 8,760 hours a year, while the other components turn on and off as directed by strategically placed temperature and humidity sensors. The table to the left shows what the typical year might look like in both northern and southern states:

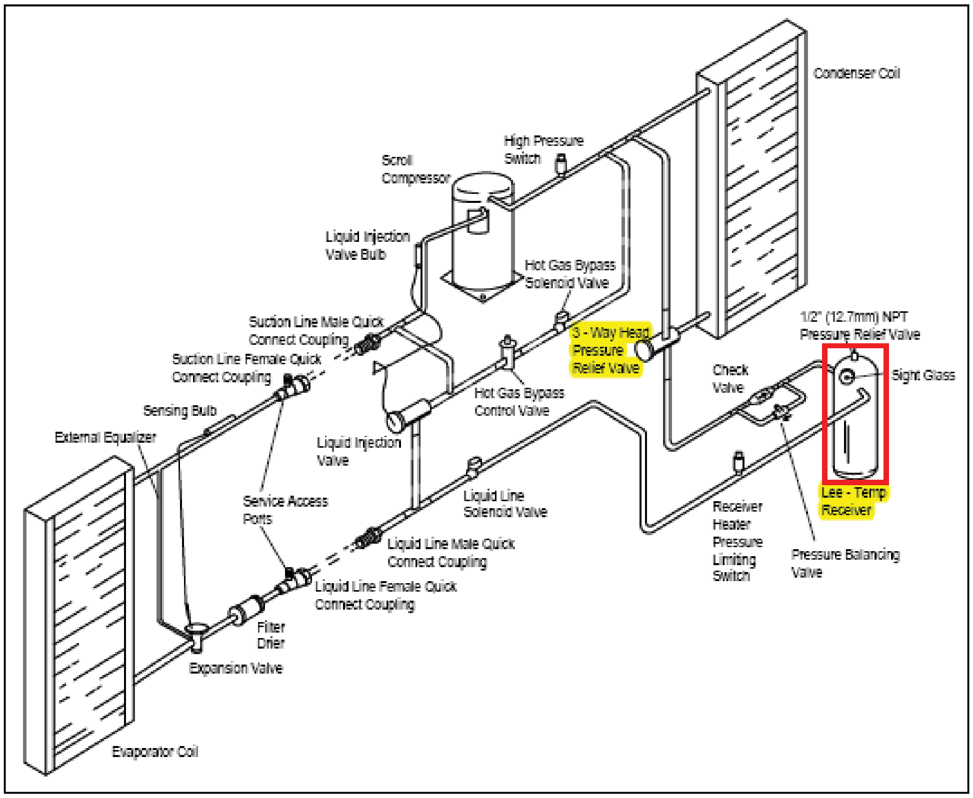
% OF OPERATING TIME (north/south)	TASK
30%/50%	COOLING
0%/20%	Dehumidifying
10%/20%	Dehumidifying & Heating
10%/5%	Humidifying
30%/5%	Cooling & Humidifying

Naturally, these percentages will vary depending on the room conditions, the heat load, and your geographical location. Your Liebert sales associate will calculate the load represented by your room as a prerequisite to recommending a precision air conditioning system. From that calculation, he can pretty well predict how the system will operate over a year's time.

Not surprisingly, comfort systems are designed to operate whenever people are occupying the area. That usually turns out to be 8 hours a day and five days a week, but only during the cooling season. A good average number for that is 1,200 hours a year.

Low Ambient Operation:

Another consideration is cold weather operation. Comfort systems with outside heat exchangers are typically inoperable when outside temperatures drop below about 40°F due to liquid slugging and evaporator freeze-up. Even systems equipped with a "low ambient" option only operate down to 0 degrees at best, unless it's windy. A precision system, by way of comparison, will operate perfectly well down to -30 °F. The diagram to the right shows one method of low ambient operational control for Liebert small systems, involving a "Lee-Temp" receiver and a "3-way head pressure relief valve". During operation in cold ambient conditions, the system may encounter a low head pressure condition. When this happens, the 3-way head pressure relief valve closes. The Lee Temp receiver, which is a refrigerant reservoir, then supplies refrigerant to the



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evaporator unit while the condenser coil fills with refrigerant. As the condenser coil fills, less of the coil surface area is available for cooling of incoming refrigerant. Thus, the temperature will begin to climb, eventually restoring nominal system head pressure levels. When the proper head pressure is restored, the 3-way head pressure relief valve opens to allow normal system operation.

Some Liebert models offer an exclusive option for cold weather operation - GLYCOOL™ free cooling. When outside temperatures drop below +60 °F, the system shifts to use mother nature as the primary source of cooling instead of the compressor. Running without the compressor at low ambient temperatures is substantially less expensive and extends compressor life.

Air Filtration:
Dust can ruin data and computer components. Dust in the heads of tape and disk readers can physically damage storage media. Dust also accumulates quickly on charged electronic components. Get enough of it, and cooling capacity diminishes, causing the affected components to operate at temperatures in excess of design specifications. That could lead to shorter service life and premature failure. Comfort systems typically use disposable filters (if any) similar to those used in residential forced-air furnaces. They're about 10% efficient. The filters on a Liebert precision air conditioning systems take the form of an internal filter chamber, and they're about 40% efficient.

Service and Support:
Critical environments require high availability of critical support systems. Therefore, it is important that these systems operate reliably, and that their performance is tuned specifically to control the environment for the computer systems with which they are deployed. Precision air systems often feature greater internal redundancy of components than comfort cooling systems, allowing them to continue operating in the event of some failures. In addition, they are supported by factory-trained, locally-based installation, service and support partners that are accustomed to the needs and sensitivities of working in the data center environment. For Liebert systems, 24-hour service is available and all critical components are stocked locally. Because even a short amount of downtime can impact the bottom line, leading precision air systems are designed for serviceability.

Cost Comparison:
In the long run, doing things right the first time is the best way to save money. And we think we've pointed out why a Liebert precision air conditioning system is a lot more right for your computer room than any comfort system. We'd like to compare purchase prices. Unfortunately, a precision system vs. a comfort system is an apples-and-oranges situation, and we really can't. You'll have to do that yourself.
But there is one big economic advantage we can offer you: lower operating costs. Operating a Liebert precision air conditioning system is less expensive than trying to do the same thing with a pieced-together system based on a comfort air conditioner. Here's what we mean.

Let's start with the following assumptions:

- Each ton of total cooling requires 1.0 horsepower (or 0.746 kw).
- The motors on the compressors and fans are 90% efficient.
- Electricity costs 6¢ per kilowatt hour.
- You'll need to humidify November through March (3650 hours).
- A 0.90 sensible heat ratio (SHR) for the Liebert system.
- A 0.60 sensible heat ratio (SHR) for the comfort system.

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We first calculate the cost per ton for a year:
(0.746 kw/ton x 8760 hrs/yr x $0.06/kwh) / 0.9 efficiency = $446/ton/yr

The cost per sensible ton of cooling for the Liebert systems would then be:
$446 / 0.9 SHR = $496

And for the comfort system, it would be:
$446 / 0.60 SHR = $743

So, it costs an extra $247/ton of sensible load to run a comfort system for a year. That confirms our earlier rule of thumb that it takes three tons of comfort capability to equal two tons of precision capability.

Now, let's look at the cost of rehumidification.

First, we calculate the latent cooling that occurs per ton of sensible cooling.

For Liebert, that's:
(12000 Btu/ton / 0.9 SHR) – 12,000 Btu/ton = 1,333 latent Btu/ton

For a comfort system, that's:
(12000 Btu/ton / 0.6 SHR) – 12,000 Btu/ton = 8,000 latent Btu/ton

The difference is 6,667 Btu. That means the comfort system expends 6,667 Btu of energy per ton of sensible cooling removing humidity from the air that must be replaced to maintain the specified moisture content of 45% ±5%.

The added cost of rehumidification is: (6667 Btu/ton x 3650 hrs/yr x $0.06/kwh) / 3413 Btu/hr/kw = $427/ton/year

So, when you add up all the cooling and rehumidification costs, it's going to cost you and extra $674/ton of sensible cooling to run a comfort-based system at $0.06/kwh.

Supporting Information

Page 6 offers a summary chart, comparing important features of precision cooling versus comfort cooling.

Pages 7&8 offer a summary of ASHRAE Thermal Guidelines for Data Processing Environments.

Precision Versus Comfort Cooling Summary

Requirements	Comfort Cooling System	Liebert Precision Cooling System
Cold Weather Operation	Many claim 0°F option but that is a fan On/Off cycling control. If there is very much wind they are only good to around +20°F.	Liebert Precision Cooling Systems perform down to -30°F. (Also GLYCOOL free-cooling option available)
High Sensible Heat Ratio	Typically 0.6-0.7. Designed to cool people. Will waste energy removing humidity unnecessarily, requiring rehumidification.	Typically 0.85-0.95. Up to 58% higher efficiency on sensible cooling, plus minimal humidification cost.
Optimized Light Load Level Operation	Typically not available. Light loading will cause stress on compressors due to frequent cycling	Various load level optimization features such as hot gas bypass, 4-step compressors with unloaders, or digital scroll compressors to allow for light load operation without frequent compressor cycling
Operational Standards	Designed for seasonal workload, 8 - 10 hours per day. Approximately 1200 - 2400 hours per year. (i.e. office hours during the cooling season)	Designed for operation when electronic equipment is generating heat - 7x24x365, 8760 hours per year.
Redundant Components	Varies - Typically redundant components are not standard.	Many critical components are redundant in systems 8-ton and larger, such as dual compressors, fan motor belts, and dual refrigerant circuits
Humidification and Dehumidification Control	Not available (Additional systems needed)	Standard (but can be ordered without to reduce cost if needed)
Enhanced, Web-Enabled Communication	Typically not available.	Web-enabled monitoring, alarm notification, and set-point adjustment capability is a feature available for all Liebert Precision Cooling Systems.
Redundant Operation Control	Not available (Additional systems needed)	Redundant operation control components are available to allow automatic operation switchover from one Liebert unit to a second unit for equalizing operation hours or in response to one unit's alarm conditions.
System Filtration	Standard throwaway furnace filter.	High Efficiency – 4" deep pleated type.
Service	Varies	Available 7x24x365 thru a Liebert Certified USA Contractor
Parts	Varies	Available with service from local stock.

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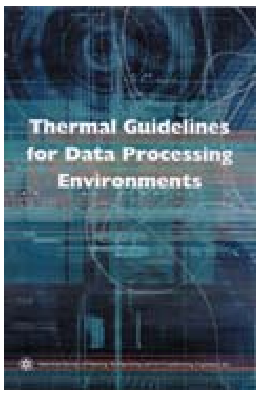

ASHRAE Thermal Guidelines for Data Processing Environments

"Recent trends toward increased equipment power density in computer room environments can result in significant thermal design and operational issues, with the potentially undesirable side effects of decreased equipment availability, wasted floor space, and inefficient cooling system operation. There is often a mismatch of IT equipment environmental requirements with adjacent equipment requirements or with facility operating conditions and, thus, a strong need to find common solutions and standard practices that facilitate IT equipment interchangeability while preserving industry innovation."

"This ASHRAE guideline provides equipment manufacturers and facility operations staff with a common set of guidelines for the design and construction of their respective equipment or facility, thereby aiding in maximizing the performance and health of the facility and its contents…"

Specifically, this guideline offers details on equipment environment specifications, facility temperature and humidity measurement, equipment and facility layout, and equipment manufacturer's heat and airflow reporting.

Contributors to this guideline: Computer Manufacturers, Support Equipment Manufacturers, Consulting Engineers, Academic and Research Institutions, Data Center Design Software Companies

Environmental condition recommendations are defined by classes:
The conditions for Classes 1 through 4 are the result of consensus among the many environmental specifications of manufacturers of IT equipment. They include "***recommended***" conditions, and "***allowable***" conditions. Per ASHRAE, ***facilities should target operating in the recommended range***.

Class Definitions:

Class 1: "Typically a data center with **tightly controlled environmental parameters** (dew point, temperature, and relative humidity) and **mission critical operations**; types of products typically designed for this environment are enterprise servers and storage products."

Class 2: "Typically an information technology space or office or lab environment with **some control of environmental parameters** (dew point, temperature, and relative humidity); types of products typically designed for this environment are small servers, storage products, personal computers, and workstations."

Class 3: "Typically an office, home or transportable environment with **little control of environmental parameters** (temperature only)…"

Class 4: "Typically a point-of-sale or light industrial or factory environment…"

See Page 8 for a chart which shows the recommended environmental operating conditions, defined by class:

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PRODUCT OPERATION					
Class	Dry Bulb Temperature (F)		Relative Humidity (%)		Max Dew Point (F)
	Allowable	Recommended	Allowable	Recommended	
1	59 – 89.6	68 – 77	20 – 80	40 – 55	62.6
2	50 – 95	68 – 77	20 – 80	40 – 55	69.8
3	41 – 95	N/A	8 – 80	N/A	82.4
4	41 – 104	N/A	8 – 80	N/A	82.4