SOLUTIONS FOR SPECIAL CONSTANT ENVIRONMENTS:

Meeting the challenges of critical temperature and humidity control. Climate control tailored for labs, medical imaging rooms, art vaults, archives and museums.

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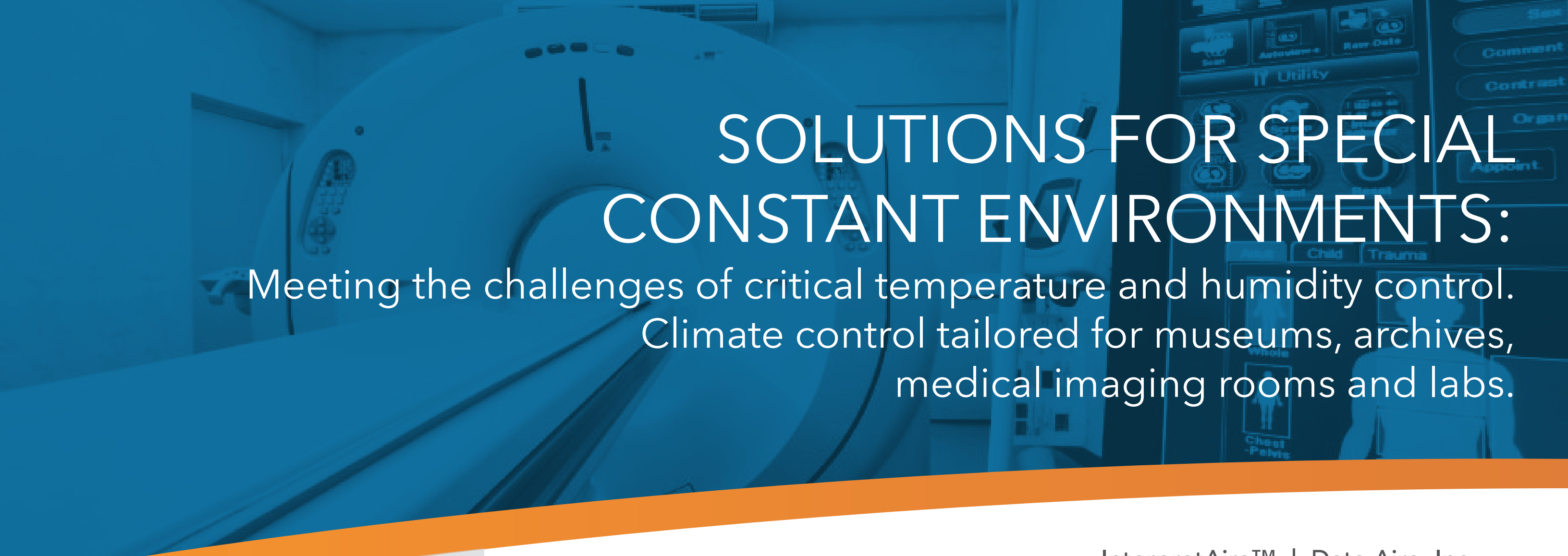

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BEYOND CRAC CAPABILITIES

Today's most advanced computer room air conditioning systems are only designed to control the climate in data centers. They aren't designed to address the unique environmental control needs of other applications where both temperature and humidity must be managed within a narrow range at the same time there is no heat being generated in the space. These Special Constant Environments call for a new approach that unites facility operator and HVAC technology provider in an analysis of all factors relevant to the installation. This offers a path to an effective and energy-efficient solution.

Facilities such as laboratories and medical imaging rooms, as well as museums and archives filled with sensitive and irreplaceable materials, fulfill roles as vital to society as the most critical data-handling installations. Yet their environmental control requirements are significantly more challenging than those addressed by standard Computer Room Air Conditioning (CRAC) solutions. Why are CRAC systems not up to the job of protecting these specialized environments? What kind of technology is? And how should you approach the process of selecting a solution that's matched to your specific needs?

THE MOST DEMANDING ENVELOPE

Let's begin by establishing what defines these exceptionally demanding installations, according to one of the recognized experts in the industry. Ernest A. Conrad, P.E., is principal in charge of Conrad Engineers and past President and CEO of Landmark Facilities Group, Inc., an engineering firm specializing in climate control for museums, special collections and historic facilities. A six-part classification system copyrighted by Conrad categorizes all buildings or individual room spaces. These range from Uncontrolled structures, such as buildings with no installed heating or cooling systems, through Partially Controlled structures with mechanical systems for temperature control only, to Climate Controlled structures that typically are designed to be humidified. The highest of two tiers within this Climate Controlled category is designated Special Constant Environments—precision temperature and humidity control with no seasonal drift. Ernest Conrad explains that "Facilities of this type could likely maintain a year-round temperature between 70°F (21°C) and 68°F (20°C), with humidity levels selected to range between 50% and 40% RH, or perhaps even smaller." Conrad notes that this represents an overall annual RH range of ±5%, and the accuracy of instrumentation controlling such facilities would achieve or surpass ±1°F and ±1% RH.

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Table 1. Classification System for Identifying the Climate Control Potential for Buildings

Category of Control	Classification Designation	Practical Limit of Climate Control	Systems Employed	Expected Benefit	Typical Construction Features	Typical Structure Types
Uncontrolled	I.	None	No Systems	None	Open Structure	Privy, stocks, bridge, sawmill, well
Uncontrolled	II.	Ventilation	Exhaust fans, open windows, supply fans, attic venting; no heat	Reduce summer temperature extremes; reduce moisture accumulation	Sheathed post and beam	Cabins, barns, sheds, silos, icehouse
Partial Control	III.	Heating, ventilation	Low level heating, summer exhaust ventilation, humidistatic heating winter control employed	Summer: same as II. Winter: good temperature control and limited humidity control; no winter occupancy	Uninsulated masonry, framed and sided walls, single-glaxed windows.	Boat, train lighthouse, rough frame house, forge
Partial Control	IV.	Basic HVAC	Ducted low level heating; summer cooling, on/off control; DX cooling, some humidification; reheat capability	Reduction of all T&H extremes year-round; winter maximum indoor temperature 60 degrees F.	Heavy masonry or composite walls with plaster; tight construction; storm windows	Finished house, church, meeting house, store, inn
Climate Controlled	V.	Climate control with seasonal drift	Ducted heating; cooling, reheat and humidification with control dead band	Precision T&H control, but gradual season drift allowed	Insulated structures, double glazing, vapor retardant, double doors	Museums, research libraries, galleries, exhibits, storage rooms
Climate Controlled	VI.	Special constant Environments	Special heating, cooling, and humidity control systems with precision constraint stability control	Constant year-round T&H without drift	Metal wall construction, interior rooms with sealed walls and controlled occupancy	Vaults, storage rooms, cases

"Why are CRAC systems not up to the job of protecting these specialized environments?"

Table 2. Sample Integration of Preservation Approaches in Buildings

Category of Control	Classification Designation	Likely Environmental Range	Collections	Use	Typical Structure Types
Uncontrolled	I.	T: 100°F (38°C) -10°F (-25°C) RH: +/-40% 100% - 20%	Repros, hardy tools and wagons	No occupancy; open to viewers year-round; no locks on building	Privy, stocks, bridge, sawmill, well
Uncontrolled	II.	T: 90°F (32°C) 32F (0°C) RH: +/-30% 90% - 30%	Educational repros, hardy tools, machinery, wagons, hardy carriages, vehicles	No occupancy; spcial events access	Cabins, barns, sheds, silos, icehouse
Partial Control	III.	T: 80°F (26°C) 50°F (10C) RH: +/-20% 70% - 30%	Period rooms, hardy textiles, furniture, metals, ceramics, no inlays or sensitive materials	Summer tour use; closed to public in winter; no occupancy	Boat, train lighthouse, rough frame house, forge
Partial Control	IV.	T: 75°F (24°C) 60°F (15°C) RH: +/-15% 60% - 30%	Many museum materials, books, paper, special cases as needed	Staff in isolated rooms - gift shop; walk through visitors only; limited occupancy; no winter use	Finished house, church, meeting house, store, inn
Climate Controlled	V.	T: 75°F (24°C) 70°F (21°C) RH: +/-10% 55% - 35%	Fine arts, inlays, conserved materials, most museum materials, finely crafted	Education groups; good open public facililty; unlimited occupancy	Museums, research libraries, galleries, exhibits, storage rooms
Climate Controlled	VI.	T: 70°F (21°C) 68F (20°C) RH: +/-5% 50% - 40%	Unstable photographs, panel paintings, bronzes, extemely old materials	No occupancy; access by appointment	Vaults, storage rooms, cases

Source: National Archives

A TEAM APPROACH IS VITAL

There are many considerations in non-data room applications/Special Constant Environments. This makes it important that all those involved in the equipment-selection process recognize difficult applications at the design stage and select equipment accordingly. Landmark's Ernest Conrad points out that, "With a commercial marketplace that gives you a choice of more than 8,000 different climate-control design combinations, it takes an analytical, step-by-step team process to reveal the single most appropriate option." Close coordination between facility management and technology suppliers is indispensable when evaluating these factors.

> *"Close coordination between facility management and technology suppliers is indispensable when evaluating the factors."*

ROOM CONSIDERATIONS

The first and most important requirement for good climate control in a space is that the envelope surrounding the space must be tight. At a minimum, "tight" means the walls, floor, and ceiling enclosing the space must not have cracks or holes that are open to the outdoors or to adjacent spaces. The tighter the control you want to maintain in the room, the tighter the room construction required.

THE HUMIDITY FACTOR

A powerful force called vapor pressure is always struggling to equalize humidity between the controlled space and the spaces next to it. The greater the humidity difference between the controlled space and the area around it, the more powerful this force and tighter the envelope must be to hold your humidity setpoint.

The biggest humidity difference is usually between the controlled space and the outdoors. *Any* opening to the outdoors must be tightly sealed or good humidity control will be extremely challenging. Doors and windows to the outdoors are the worst. If you remove the molding from a door or window you will notice that there are huge gaps between the wall and the frame of the door or window. Again, at a minimum, these spaces around the door and window frames must be stuffed with insulation and caulked in place. If nothing else, at least run a bead of caulk along the molding where it meets the wall and the window frame to cut down on leaks. The door should have weather stripping where it meets the door jamb and a good threshold that seals tightly against the bottom of the door. If the door is open to an adjacent space, a door sweep should be added to the door to prevent air passing beneath it.

> "It's also important to quantify all moisture inputs to a climate-controlled structure."

THE PROBLEM WITH PASS-THROUGHS

Penetrations through the walls, floor and ceiling that were made for things like wire, conduit, pipes, and ductwork to pass into the room are the next biggest offender. The annular space around all these penetrations should be stuffed with insulation that is then caulked in place. This is often where the worst leaks in the envelope occur.

Walls that stop at the lay-in ceiling like those in most office spaces are a problem. The empty space above the ceiling tiles is called the ceiling plenum. The tiles in the ceiling are porous and do not seal tightly against the ceiling grid. Humidity from any space in the building that shares the same ceiling plenum, passes freely through the tiles into the space you are trying to control. Walls in the controlled space must extend from the floor of the space to the roof or to the floor above. It may be impossible to control climate conditions in a space if the walls stop at the ceiling. If the walls do not go to the structure, add "walls" of polyethylene sheeting to run from the top of the wall of the controlled space to the structure. Overlap the sheets by 12" in places where two sheets meet and tape the seams closed. Seal the sheets to the top of the wall of the controlled space and the structure above with caulking. Any space where the walls meet the floor and the structure above should be caulked to prevent leaks.

ISOLATION BY AIRLOCK

In places where extremely tight control must be maintained, it may be necessary to add an airlock entering and leaving the controlled space. This is a vestibule space with two doors, one coming from the adjacent space and the other going into the controlled space itself. When a person enters the vestibule from the adjacent space, that door closes before the person opens the door to the controlled space. This significantly reduces the amount of untreated air that enters the space when people come and go.

RUN A HUMIDITY LOAD

Along with controlling water vapor transfer, it's also important to quantify all moisture inputs to a climate-controlled structure. The design engineer must run a humidity load to quantify the moisture inputs. The humidity load totals up all the sources of humidity coming from outdoors, adjacent spaces, and from within the room itself. The total of all these humidity loads is then used to select equipment capable of removing that amount of moisture from the air. For instructions on how to run a humidity load see ASHRAE publication Humidity Control Design Guide.

COOLING LOADS MATTER TOO

Of course, humidity is only part of the climate-control equation. Analysis is needed to achieve precise temperature regulation as well. There are six primary sources of cooling loads:

- **Outdoor Air** –Outdoor air is required by building codes to be introduced into occupied spaces for indoor air quality. Unconditioned outside air should never be introduced into a space where humidity needs to be controlled. Outdoor air should be introduced through equipment that is dedicated to bringing the outdoor air to the temperature and humidity that is required in the space. Only then should the outdoor air be allowed to go into the controlled space.
- **Solar** – Sunlight passing through the glass in windows, doors and skylights can be the largest cooling load depending on the square footage of the glass. Concentrated where the light lands, it has 10 times the heat energy of other loads.
- **Transmission** – Heat transferred through walls and roofs with different temperatures on each side, in summer this may have only a third of its winter influence, when temperature differentials can reach 70°F (21°C).
- **Lights** – Since these only generate heat when they're on, they can amount to 90% of additional heat generated in the room when they are on, and 0% when they are off.
- **People** – Typically a small source of heat energy, this heat load ranges from nearly all water vapor (generated by sweat) in hot rooms of 100°F (38°C), to nearly all warmth in rooms below 32°F (0°C); it's about half vapor/half warmth at normal temperatures. To give you an idea, a person requires about as much cooling as a 75-100-watt light bulb.
- **Infiltration** – The movement of air through unsealed openings around doors, windows, structural cracks, gaps or porous materials.

"There are six primary sources of cooling loads."

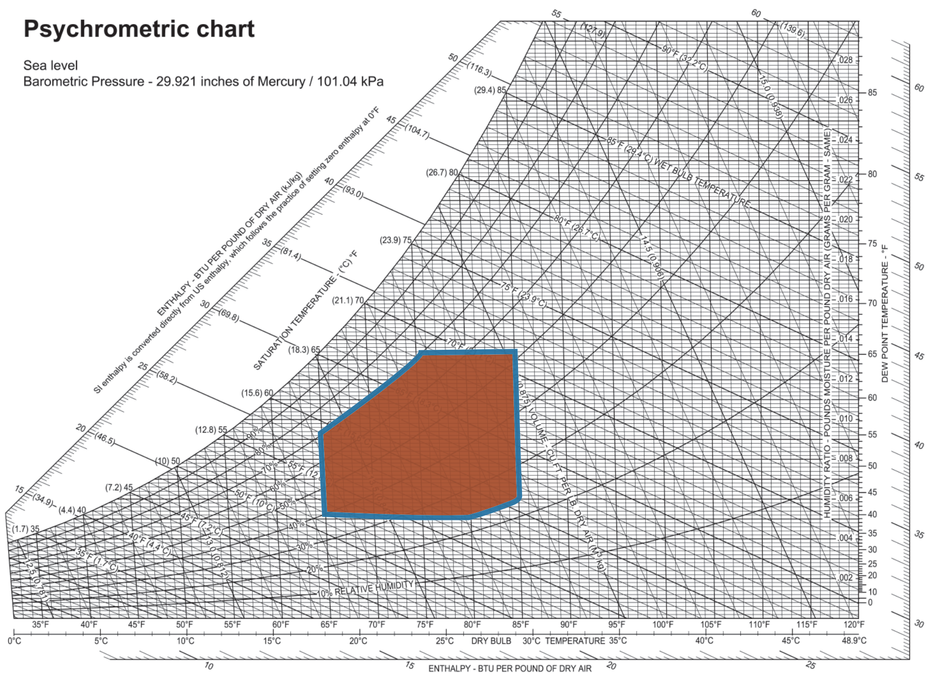
EQUIPMENT CONSIDERATIONS

It is important to note that equipment like CRAC units and other air conditioning systems use a medium temperature refrigeration system for cooling and dehumidification. For the equipment discussed in this paper to do the job, the conditions in your space must fall within a range that can be handled by these systems. If the design temperature set point is above 65°F (18°C) then medium-temperature air conditioning equipment can be used. The refrigerant pressures in this equipment generally operate within the same range as comfort cooling, although the equipment itself is significantly different from comfort cooling equipment.

Spaces with design temperatures below 65°F (18°C) normally require low-temperature refrigeration equipment. Equipment used to condition these spaces include many features not included in units designed for higher temperatures. These spaces and the equipment required to serve them are beyond the scope of this paper.

HUMIDITY LIMITS OF MEDIUM-TEMPERATURE SYSTEMS

In many commercial applications the equipment is capable of controlling anywhere in the shaded area in the window shown below. However, in applications like laboratories, archives and medical imaging rooms we must be more conservative with the target temperature and humidity to ensure success. The minimum relative humidity that medium-temperature air conditioning equipment can maintain increases as the temperature in the space decreases. At 75°F (24°C) minimum 35% humidity may be attainable in an extremely tight space. But if the space is kept at 72°F (22°C) the lowest humidity you can hope for is 40%. At 68°F (20°C) 45% is the minimum humidity and at 65°F (18°C) there is very little chance that you will get the space humidity below 50%. If you need to control a space below those minimums, then a different type of dehumidification should be used.



NO PLACE FOR STANDARD COMPUTER ROOM AIR CONDITIONING (CRAC) SYSTEMS

A CRAC unit's design is optimized for the very specific cooling loads generated by a data room environment. Spaces like laboratories and archives have completely different cooling loads. The biggest loads in a data room tend to be the smallest loads in a laboratory and vice-versa. CRAC units have insufficient heat capacity for Special Constant Environments. They're designed for data rooms where heat is always being generated by data processing equipment, and they rely on this room heat to dry the air without cooling the room. This makes standard CRAC units a poor choice for applications where this room heat is limited or may be absent at times.

"The biggest loads in a data room tend to be the smallest loads in a laboratory and vice-versa."

Special Constant Environments can be challenging because they need tight temperature & humidity control 24/7/365, even during off hours when the cooling load is low or nonexistent. Temperature control in most spaces is relatively easy; controlling humidity is the real challenge.

The manageable part of controlling humidity is adding humidity to the space. Low humidity is a persistent problem in dry climates and areas with cold winters. The same humidifiers furnished in standard CRAC units are able to maintain humidity above minimum setting in most cases. The one exception is when outdoor air that has not been humidified is being brought into the space. Great care should be taken in sizing the humidifier if this is the case.

The more difficult part of humidity control is removing humidity from the air. That process is called dehumidification and it is a problem for standard CRAC units. There isn't any moisture being generated in a data room so CRAC units were optimized to have limited moisture-removal capability when in the dehumidification mode.

Dehumidification mode means removing humidity from the air without sending any cool air into the space. The cooling coil is what removes the moisture. But it cools the air at the same time. Since we do not want to send any cool air into the space the air must be reheated to the room temperature. There are other ways to dehumidify but, for purposes of this discussion, the cooling and the heating must run at the same time to dehumidify. So, you pay to cool and dehumidify the air and then you pay again to heat the air back up to room temperature.

LIMITED AND COSTLY HEAT CAPACITY

Besides limited dehumidification capacity, there are two other issues with trying to use a standard CRAC unit to dehumidify non-data room spaces. First, there is only half as much heat capacity in a standard CRAC unit as there is cooling capacity. That means the already minimal amount of dehumidification available at full load is cut in half. You cannot increase the cooling capacity to get more dehumidification. If you do, there is not enough heat in the unit to offset the increased cooling capacity. Cold air would be delivered to the space and the space temperature will begin to drop too low. Unless there is a significant requirement for cooling from the space, a standard CRAC unit simply cannot reach the desired humidity setpoint.

The second issue is that heat in CRAC units is provided by electric resistance heating elements. In the past, increasing the size of the CRAC's electric heating elements seemed like a solution. From a power-cost standpoint, this is a costly source of heat. In a data room the electric heat runs only a handful of hours a year, so this is not an issue. In other applications though, the electric heat runs hundreds or even thousands of hours per year while in the dehumidification mode and the cost of the power to run it adds up quickly.

"Exemplifying the multifaceted solution required to meet the demands of these applications is Data Aire's InterpretAire™."

Not only does the operating cost increase when you double the reheat, this could double the size of the electrical service (wire size and circuit breaker) required, increasing installed cost. Perhaps even more problematic, using electric heating elements creates two issues in a space where—unlike a data room—dehumidification may be needed for thousands of hours a year. Electric heat makes the cost of running heating and cooling simultaneously prohibitively expensive. It also may fail to comply with evolving energy-efficiency codes that increasingly prohibit heat from new energy being used for dehumidification. This trend is expected to continue as more jurisdictions update their codes. This means that heat must be provided by recovered energy when the cooling coil is used for dehumidification.

TECHNOLOGY THAT'S UP TO THE CHALLENGE

CRAC units are not a good option for laboratories, libraries, museums, archives, or MRI suites unless you make significant modifications to them. Of course, then they aren't CRAC units at all. Exemplifying the multifaceted solution required to meet the demands of these applications is Data Aire's InterpretAire™, a packaged cooling, heating, humidifying and dehumidifying unit that has all the advantages of a standard CRAC unit, yet designed for the specific needs of constant environments rather than data centers or telecom spaces.

Jake Seuser, Data Aire product development specialist for InterpretAire, says, "By employing a cooling coil designed to remove more moisture, the InterpretAire approach provides 100% dehumidification capacity any time of the year, day or night, whether or not cooling is needed." Seuser explains that, "Of the heat needed during dehumidification mode, 75% is free heat recovered from the compressor." He adds that the unit-mounted control system provides all four required modes of operation.

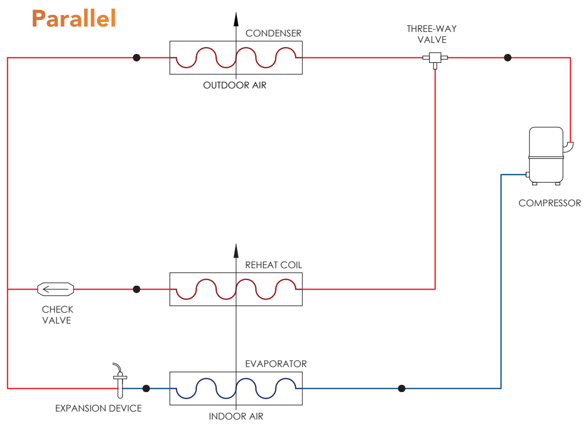
WHEN SHOULD INTERPRETAIRE BE USED?

A common question is "when should I use a piece of equipment like InterpretAire?" The safe answer is, if both humidity and temperature control are needed, and the application is NOT a data room, you should always use InterpretAire. Other equipment MAY be able to handle SOME of those applications. But why would you take a chance?

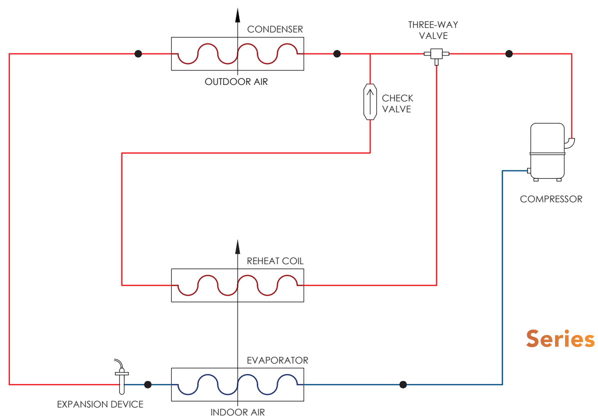
Data Aire's experience has shown that standard CRAC equipment will deliver barely acceptable temperature and humidity control in about ½ to ⅔ of non–data room applications. The biggest challenge is that it is difficult to tell in advance which ones will perform adequately and which won't.

THE HOT GAS REHEAT SOLUTION

There is a type of heat that meets these new code requirements and is a much better option for heating during dehumidification. It uses free heat that is recovered from the compressor to lower operating cost and meet code. The customer pays the cost of the cooling but the heat is free. This use of free energy is called hot gas reheat (HGRH).

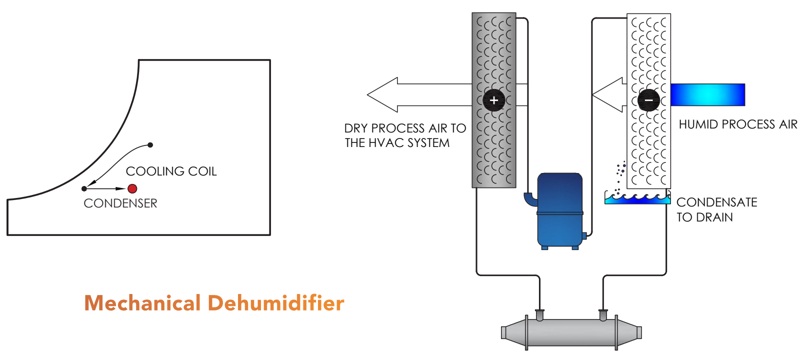


There are two types of HGRH configurations: parallel and series. Series configurations are common when reheat is needed in the capacity range of 30% to 50% of the evaporator total heat of rejection. Therefore, a traditional series configuration will produce sufficient reheat when in a properly loaded space. If the space is not loaded sufficiently, the equipment may need an additional heat load to supplement. Low-load spaces may not be the best application for a series configuration due to the reliance on supplement heat, which is often coming from electric elements.



Series

When considering the alternative parallel configuration, the application scope can be expanded. By utilizing the discharge gas of the compressor as the heating medium, the entire total heat of rejection is used for heating in the parallel setup. This results in a heating capacity greater than that of the cooling capacity. Therefore, the equipment can run heating cycles when dehumidifying. If the space requires dehumidification and heating, a parallel setup is the configuration to consider. Traditional dehumidifiers operate on this principle because it is fundamentally a straightforward way to dehumidify while not overcooling.

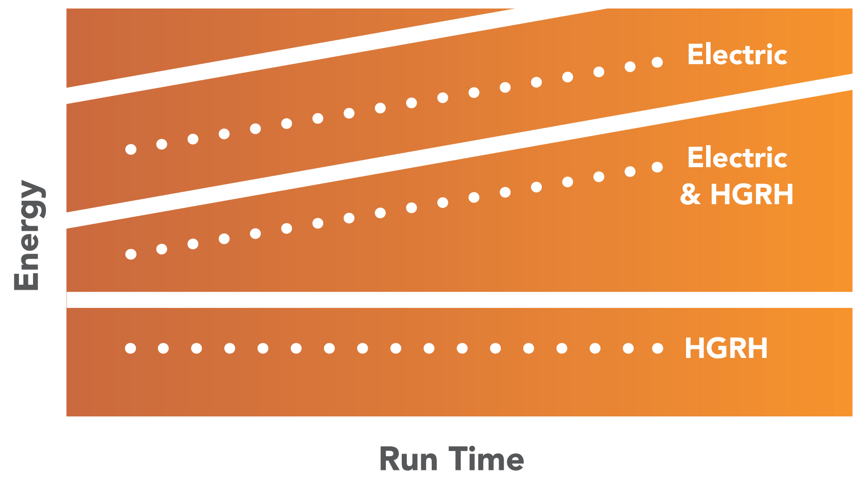


Mechanical Dehumidifier

Series Configuration: ASHRAE Journal

In either configuration, supplemental electric heat can be added during times of low temperature without the need for dehumidification. Without the need for dehumidification, the compressor should not cycle. Otherwise, humidification would need to be added back in to counteract the dehumidification of the cooling coil while the HGRH is heating.

In terms of costs, operating a system with full HGRH will offer the best energy savings. If heating is needed without dehumidification, small supplemental electric heat can be added. While this will add operating cost, the total operating cost will still be less than full electric heat, though not totally "free" as with full HGRH.



ADIABATIC AND NON-ADIABATIC HUMIDIFIERS

Finally, in order to maintain humidity control, the equipment must contain a humidifier. There are two classes of humidifiers, adiabatic and non-adiabatic. Each has its advantages and drawbacks. These should be carefully considered when deciding which to use. Adiabatic humidification uses no energy to make humidity. Spraying a fine mist of moisture in the air is a type of adiabatic humidification.

There are several other types of adiabatic cooling but only one, the ultrasonic humidifier, is self-contained, delivers the dependability and accuracy required in most spaces but does not come in a small enough package to be viable for use inside the equipment serving the controlled space. The state-of-the-art for small, packaged, non-adiabatic humidifiers today is the steam generator type humidifier.

The low first cost of steam generator humidifiers must be balanced against their operating cost. The largest operating cost is the periodic replacement of the canister that generates the humidity. Operating cost is directly proportional to the number of hours the humidifier operates. The best way to extend the life of the canisters is to construct a very tight room that requires minimal humidification.

SENSOR CONSIDERATIONS

The accuracy of a sensor is called its tolerance. Accurate temperature sensors are relatively inexpensive; ±1°F is a reasonable goal for tolerance of a temperature sensor.

Humidity control, on the other hand can be extremely challenging when tolerances less than ±5% are expected. It is important to know the limitations of the several types of equipment that can be applied to maintain temperature and humidity in a space.

One reason accurate humidity control is more difficult than accurate temperature control is the humidity sensor itself. The most common humidity sensor is a capacitance sensor. There are two considerations when selecting a humidity sensor: its accuracy and its speed of response. The more accurate the sensor and the quicker its response, the more expensive the sensor. In rough order of magnitude, costs vary from $5 to $500 each for these sensors. Response time varies from a minute or two to a few seconds for the most expensive sensors. General statements are difficult to make, but it is reasonable to expect a tolerance to range from 5% or higher for the least expensive sensor down to about 1% for the more expensive capacitance sensor.

Speed of response is just as important as tolerance. Humidity can change significantly in a couple of minutes. Once the equipment gets the message to humidify or dehumidify it takes a couple more minutes before humidity actually starts getting added or removed from the room. Sensors with high tolerances and slow response time lead to large humidity swings in the room.

Tolerance (accuracy) has been mentioned several times, so an explanation of this term may be in order. If a sensor has a tolerance of 3% humidity, that means the humidity the sensor displays is within 3% of the actual humidity in the space. If the sensor says the humidity is 50% it could be displaying precisely the actual humidity; the humidity could be 47% (50% minus 3% tolerance), 53% (50% plus 3% tolerance), or somewhere in between. You just don't know.

InterpretAire uses a high-quality sensor that is fast acting with 1% tolerance. This becomes particularly important when the readings of the sensor controlling the equipment is being compared to another in the same space.

Many rooms use one sensor to operate the climate control equipment and a different sensor to maintain the historical trend records of the temperature and humidity in the room. This is a bad idea that has led to much misunderstanding and aggravation. It is best practice for a single sensor to be used to both control the equipment and maintain the temperature and humidity trends. And that sensor should be the one furnished with the climate control equipment for several reasons.

First, the most expensive sensor in the room with the tightest tolerance and the quickest reaction time is usually the one that is controlling the InterpretAire, so it makes sense that you would want to build trends off that sensor. Second, even if another sensor in the room is fast and accurate, it does not matter. The information from that sensor is irrelevant. InterpretAire cannot react to a sensor that it is not connected to. Why even bring a second sensor into the conversation?

> *"It is best practice for a single sensor to be used to both control the equipment and maintain the temperature and humidity trends."*

APPLICATION-SPECIFIC CONSIDERATIONS

Laboratories, medical imaging rooms, museums, archives and art vaults share a common need for equipment with the ability to deliver warm air while operating in dehumidification mode, cold air in the cooling mode, and the capability to switch seamlessly between the two. The following options should be included on equipment serving all these applications.

- Hot gas reheat to reduce energy use when dehumidifying
- Humidifier to maintain the minimum humidity set point
- Silicon Controlled Rectifier (SCR) reheat, which pulses rapidly to control temperature within a narrower range for greater accuracy
- Intelligent controls for Internet-connected monitoring, alarm notification and optional integration with a central building management system.

Pay careful attention to the temperature and humidity set points and tolerance around those set points required by each application. Achievable set points were discussed above, but the acceptable tolerance around those set points is just as important. Sometimes the expectations are too high for the type of equipment being used.

A reasonable temperature tolerance is 2°F or greater. One-degree temperature tolerance can be achieved on some applications but requires careful consideration of the load and space characteristics. Take caution if one-degree tolerance is needed.

Likewise, be very cautious if 3% tolerance is required for humidity. It may be achievable if the load and space characteristics are acceptable but 5% humidity tolerance is much more easily achieved.

Though they have much in common, the unique needs of each application should be considered when sizing equipment for the space.

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MEDICAL IMAGING ROOMS

An MRI suite usually consists of three separate spaces: a scan room, a control room, and an equipment room (see Figure One). The scan room is where the MRI machine is located. The equipment room contains the datacom equipment that generates the MRI images, a small chiller that cools the donut-shaped MRI magnet, and other items that support the MRI machine. The control room is a small space with a chair and a console for the technician who operates the MRI when scans are in progress. All these spaces require cooling and humidity control. The climate control equipment is usually located in the equipment room and consists of a single unit that is either mounted on the floor or hung from the ceiling.

"MRI climate control equipment is usually located in the equipment room and consists of a single unit that is either mounted on the floor or hung from the ceiling."

Source: [MRI Questions Design Guide]

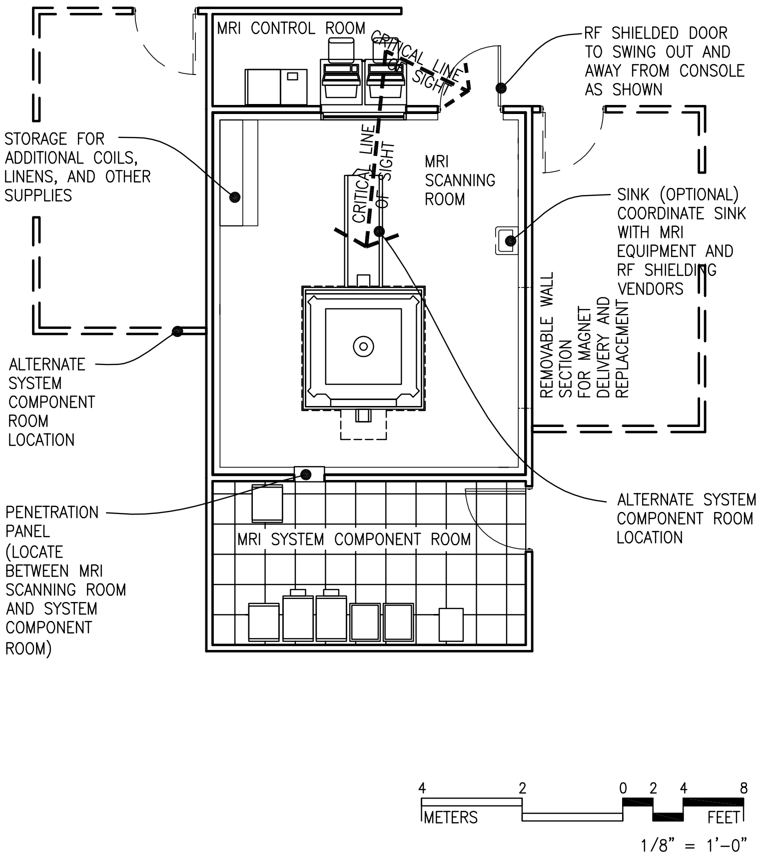

Figure One

Figure Two shows the equipment-cooling requirements of a typical MRI suite. The design engineer takes this data and adds lighting, people, and other air conditioning loads to determine the size of the unit(s) required to condition the spaces. The two rightmost columns in figure two list the maximum and minimum temperature and humidity allowed in the spaces. When space conditions are outside of this range the MRI may not function correctly. Manufacturers have been known to withdraw warranty coverage if temperature and humidity are not maintained within these parameters 24/7/365.

The tightest control is required in the equipment room. Note in figure two that the In Use and Standby heat output BTU/H in all three rooms change in tandem. Once supply airflow among all rooms is balanced, adequate climate control in all spaces can be maintained by one climate control unit, in most cases. The sensor operating the climate control equipment should be located in the equipment room.

The difference between the In Use and Standby loads for the MRI is about 40%. But they are often turned off at night or when they will not be used for a long period of time. When the MRI is turned off, the heat load disappears, but the need for humidity control remains.

HVAC REQUIREMENTS

CUSTOMER TO PROVIDE THE NECESSARY HVAC REQUIREMENTS FOR THE TOSHIBA EQUIPMENT TO OPERATE PROPERLY.

AMBIENT TEMPERATURE SHOULD BE IN ACCORDANCE WITH THE FOLLOWING FOR CORRECT EQUIPMENT OPERATION AND PATIENT/OPERATOR COMFORT.

ROOM NAME	HEAT OUTPUT (BTU/H)				TEMP. (°F)	HUMIDITY (%RH)
	IN USE		STANDBY (NIGHT TIME)			
MRI SCAN ROOM	TOTAL	4,437	TOTAL	2,049	60.8-75.2°	40-60% (NO CONDENSATION)
MAGNET		4,095		1,707		
FILTER PANEL COVER		342		342		
CONTROL ROOM	TOTAL	2,049	TOTAL	2,049	60.8-86.0°	40-75% (NO CONDENSATION)
HOST CABINET		1,365		1,365		
MONITOR		342		342		
CONTROL BOX & CONTROL PAD		342		342		
EQUIPMENT ROOM	TOTAL	61,763	TOTAL	36,854	68.0-75.2° ±1.8°/DAY	40-70% (NO CONDENSATION)
TRANSFORMER CAB.		1,707		1,707		
REFRIGERATOR		9,896		9,896		
GRADIENT CABINET		17,061		2,047		
CONTROL CABINET		17,061		13,649		
RF CABINET		12,284		5,801		
SHIM AMP		2,388		2,388		
MAGNET FAN BOX		683		683		
FILTER PANEL COVER		683		683		
POWER SYSTEMS	TOTAL		TOTAL			
PCDU		4,300		N/A		*NOTE: FINAL HEAT OUTPUT OF EQUIPMENT ROOM MUST INCLUDE SITE SPECIFIC POWER SYSTEM AND ANY OPTIONAL ITEMS. SEE SHEET A1 FOR ADDITIONAL HEAT OUTPUT OF OPTIONAL ITEMS.
VRDU		17,302		N/A		

Figure Two

In essence, an air conditioner is required when the MRI is in use and a dehumidifier is needed when the MRI is turned off.

Humidifiers should always be included in equipment serving medical imaging suites. Hot gas reheat should be supplied for reheat in the dehumidification mode.

MUSEUMS & ARCHIVES

Effectively storing and protecting sensitive collections such as books, art or historical objects requires making informed compromises based on an accurate understanding of the processes most likely to cause degradation. These processes—chemical, biological and mechanical—as well as the environmental conditions that drive them, vary depending on the nature of the items in a collection. Countering any or all of them requires an environmental control system sophisticated enough to precisely manage both humidity and temperature.

"Effectively storing and protecting sensitive collections such as books, art or historical objects requires making informed compromises."

Chemical deterioration is driven by heat in combination with RH. Metal museum objects are at risk of corrosion under high-RH conditions. Warmer temperatures and higher RH also are the major environmental risk for the organic materials, such as paper, dyes and leather, in libraries and archives. These can become brittle, discolored and faded, with their degradation accelerating as conditions become warmer and more humid. Chemical change occurs gradually, and varying rates of change over time do not, by themselves, cause additional harm. When striving to minimize chemical damage, keeping temperatures as low as possible without risking biological or mechanical deterioration, and minimizing dew point during summer months, are good basic practices.

Biological damage is the work of organisms, the most troublesome of which typically are insects and mold. While warmer temperatures do increase this risk and contribute to the ultimate damage it can cause, RH actually plays the dominant role. Moderate temperatures and higher RH fuel biological activity. Consequently, your environmental control system should be capable of preventing high RH while maintaining a moderate temperature, and keeping dewpoints low throughout the summer.

Mechanical damage is physical destruction of organic materials that are inclined to absorb moisture (i.e. hygroscopic materials). Here, too, RH is the principal culprit. When they're low in moisture, these objects tend to contract and grow brittle. When they absorb moisture, they swell up and become softer. At either extreme, the object is susceptible to tearing, deforming and cracking. Mechanical damage is aggravated by frequent cycles between low and high humidity, so once again, the moisture-management precision of an environmental control system designed for Special Constant Environments can be of considerable value in minimizing RH variations—elevating dewpoints in winter and reducing them in summer.

Balancing the management of these risks requires an accurate assessment of their impact on your specific collection. Valuable resources, including decay metric algorithms, as well as software and hardware for preservation-analysis efforts, are available through the Image Permanence Institute, a non-profit, university-based laboratory.

Humidifiers should always be included in equipment serving medical imaging suites. Hot gas reheat should be supplied for reheat in the dehumidification mode.

LABS

Whether a facility is engaged in basic research, pharmaceutical development or processing medical specimens, the temperature and humidity control required can warrant treatment as a Special Constant Environment. Temperature and humidity setpoints and tolerances can vary significantly between different types of laboratories. And special isolation considerations, including negative pressure, may apply due to the presence of chemicals and potentially hazardous biological materials. In addition, climate conditions within a lab can have a direct bearing on results, as well as the longevity of equipment and supplies. Ensuring the health and comfort of laboratory staff, who may in some cases be present around the clock, also is a prime consideration.

"Climate conditions within a lab can have a direct bearing on results, as well as the longevity of equipment and supplies."

A laboratory HVAC system must be sized appropriately for the expected loads (conditions) and airflows in order to achieve its full performance potential. As suggested by the differences identified in Figure Three on the following page, however, a standard CRAC system will have difficulty interpreting and satisfying these variable cooling loads.

In a laboratory's highly variable load situation, an environmental control system's cooling function will not run long enough to provide significant dehumidification. This requires complete dependence on the dehumidification cycle. With a highly variable sensible load, an appropriate coil design should expend 30% to 40% of its energy removing moisture, and 60% to 70% on cooling the space.

Figure Three

Standard Computer Room Air Conditioning	Highly Variable Cooling Load Room
50% cooling load 24/7/365	Zero cooling load at times
Humidity removal 24/7/365	Zero dehumidification help from cooling at times
Minimal moisture removal – 80% to 90% SHR adequate	60% to 70% SHR needed
Dehumidifies < 10% of run hours	Dehumidifies ½ of the run hours

It is particularly important in laboratories that the sensor used to control the equipment is the same sensor used to generate temperature and humidity records.

Operating laboratory facilities productively and profitably requires a multifaceted approach to environmental control efficiency. A system optimized for lab use, such as Data Aire's InterpretAire, will employ a variety of techniques to achieve this.

CONCLUSION

From collections of priceless relics, and medical facilities that image patients with life-saving precision, to laboratories that advance the frontiers of human knowledge, success depends on precision environmental control of both temperature and humidity. Conventional computer room air conditioning was never designed for these roles. However today, innovative technology such as InterpretAire from Data Aire offers application-specific, energy-saving solutions tailored to the needs of these Special Constant Environments. To discuss your own specific needs, contact Data Aire to arrange a consultation at your convenience.