VERTIV.

Application Note

Preserving Precision Control of the Environment in testing labs

Executive Summary

The most important aspect of the cooling design in technical rooms is maintaining a precision control on the various parameters of air simultaneously to achieve the desired environmental conditions. Keeping this in perspective, the conditions are even more stringent for applications like "testing laboratories". In such scenarios, any unforeseen temperature /humidity variations beyond the desired limit can be disastrous, as it can impede the end products leading to inaccurate results. To counter this predicament, these testing laboratories require rigid environmental conditions with close control of temperature and humidity which is most conducive for appropriate testing results. A cooling solution which utilizes the close control of temperature and humidity can only be possible by utilizing Precision Air Conditioning Units. In this paper, the importance of tight control of the indoor air quality for such applications and the techniques to implement them are mentioned in brief.

Introduction

Testing is a process that involves repetitive examination and evaluation of products according to preset standards and norms which assess the product performance. Prior to the product launch in the market, each finished product undergoes a rigorous testing procedures to check its conformance to specifications. In this document, we have specified the various laboratory standards for some of the products related to precision cooling solutions.

Firstly, lets take a look at the norms and conditions for the following items, namely –Textile, Paper, Tobacco, Metrology, and Archives etc.

a) Textile Industry

A textile laboratory conducts several tests and checks on fabric materials according to the applicable norms and international standards (related to the industry specifications). Several testing procedures and tests are carried out which include scrutinizing the woven structure, the count of yarns in the fabric, color fastness, quality of the fabric, robustness of the fabric, weight per square meter of the fabric, and so on.

For textile laboratories, ISO 139 is referred as the standard and with the same reference, temperature of 20 deg C and a relative humidity of 65% along with +/- 2~4 unit range have to be maintained; in addition the regulation sets the following limits or tolerance for thermo – hygrometric variability:

Temperature	Relative Humidity
20 ± 2°C	65 ± 4%

Reliability and accuracy are crucial factors in textile testing. The textile products are highly sensitive to changes in temperature and specifically humidity.

b) Paper Industry

The quality of paper is greatly influenced by moisture content of inside environment and limitation in fluctuation of relative humidity is need to be controlled in order to achieve accurate test results as per ISO 187 and UNI EN ISO 2233:2001.

ATMOSPHERE "A" - UNI EN ISO 187

Temperature	Relative Humidity
23 ± 1°C	50 ± 2%

ATMOSPHERE "B" - UNI EN ISO 2233:2001

Temperature	Relative Humidity
20 ± 1°C	90 ± 2%

In Paper Testing Laboratories the data log sheet of temperature (°C) and R.H. (%) should be saved periodically or electronic log recorder according to reference acceptable limits previously described.

c) Tobacco Industry

Different analytical and rigorous tests are conducted in tobacco testing laboratory. A few physical & chemical properties such as pH, VOC, carbonyl compound etc are tested in laboratory. Other than these parameters, filter quality & smoke test are very important aspects to test a sample with the internal environment being a guiding factor to these tests. Even the testing of the filter paper is done to check the effect of the moisture content of the indoor air on the paper. Smoke test results depend on the temperature tolerance, air movement pattern etc.

Name	Use	Temp	RH
Flue gas analysis chamber	Smoking cigarettes smoked machine pumping test	22±1°C	±3%
Cigarette paper laboratory	Cigarette paper, tipping paper test	22±0.5°C	±2%
Tow Lab	Tow performance test	20±1°C	±3%
Cigarette Lab	Cigarettes, filters physical characteristics test	22±1°C	±2%

Mentioned below are some important tests which depict the temperature and the RH tolerance for various industries and the laboratory based tests.

d) Dimensional Metrology

International standard mentions about temperature & its tolerance limit requirement in dimensional metrological labs. Fine calibration and precise measurement are fundamental key elements of application such as CMM room. The geometrical specification measurement and testing largely depending on constant temperature (20°C+/-0.5°C).

As per the psychometric chart moisture content is dependent on parameters such dry bulb temperature & wet bulb temperature with maintaining a close temperature on relative humidity.

20 ± 0.5°C	45 ± 5%

e) Archives

Temperature and relative humidity have a significant impact on the condition of tape libraries and archive collections due to which they need to be dealt with in more detail.

Swing in temperatures can damage some materials directly. High temperatures can cause wax seals to soften or even catalyze the combustion of cellulose nitrate film. At lower temperatures, organic materials, including plastics, become brittle, making them prone to physical damage if handled improperly. Certain types of collection, mostly photographic and audio visual collections require more closely controlled RH and temperatures.

Air movement is an important factor too

Besides tight tolerance in temperature, relative humidity & air cleanliness, air movement is also an important factor. Comparatively lower air velocity is always recommended in laboratory area in order to maintain accuracy of test results and maintaining a proper condition for the preservation of material.

Firstly, it is to be ensured that there is a clean, uncontaminated air movement through the entire space. Else the damp, cold surfaces could lead to imbalance in the moisture content and there could also be a manifestation of pests in stagnant air.

Mentioned below are some common practices to maintain optimum air movement:

a) Supply air flow in laminar pattern
b) Low velocity of supply air to ensure smoother airflow and quiet operation
c) Fixing supply air vane in such manner that direct air throw to testing bed is avoided
d) Collection of return air in appropriate manner based on application demand
e) Free return air or guided return air thru return ducting or opening
f) Optimum external static pressure selection to overcome pressure drop across the air path movement

Defining the pre-requisites and conditions for Optimum testing

Optimal testing is achieved in a favorable environment which caters to industry-specific norms and practices
Refer to the table in **Table 1** to gauge the desired values for different Lab types:

Application	Papermaking	Tobacco	Textile	Museum	Measuring Room
DBT ˚C	23	22	20	20	20
RH %	50	60	65	40	40~60
Temp Accuracy ˚C	±1	±1	±2	±1	±0.5
RH Accuracy %	±2	±3	±3	±3	±5

Table 1 - Standard values for certain Substances and Lab type

Laboratory (read Physical Testing Lab) - Driving factors

The physical testing lab generally has an area in the range of 30-50 square meters. The lab hosts the physical testing equipment for conducting a plethora of tests and checks for factors such as tensile strength, abrasion, pilling, crocking, dimensional measurements, and sample pre-conditioning to mention a few.

Another quotient that has to be taken into consideration is moisture. Moisture affects the mechanical behavior of textile fiber, paper pulp, and tobacco in different ways. As it affects the materials differently, the change in the mechanical properties due to moisture will vary. Therefore, it depends on the composition of material as well as the amount of moisture found in that sample.

A certain pre-requisite is to use an air-lock with double doors to effectively maintain industry-best standards in the testing environment.

- **Requisites**

  Favorable conditions and patterns help in streamlining the testing procedure.

  Mentioned below is a list of those objectives that are pre-requisites and favorable for a smooth operational flow:

  - Extreme and enhanced control of Temperature and Humidity. The factors depend on the Dry Bulb Temperature (+ / -) 1 degree Celsius and the Relative Humidity (+/ –) 3%.
  - Regulation of Sensible Cooling capacity to meet the cooling requirement
  - Modulating and adjusting reheat of the air
  - Direct Expansion ducted units.

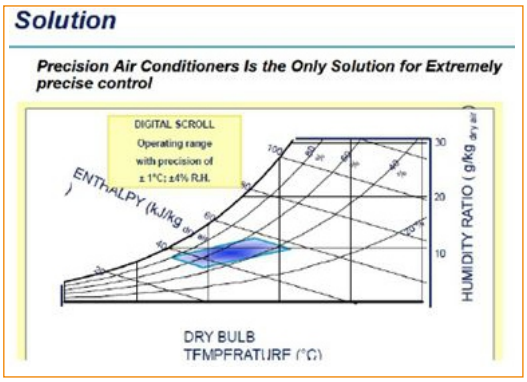

Figure 1 – Schematic diagram of Objectives

Technical attributes of the components

The following are the technical attributes of the components:

- **Construction:** Double skinned and ductable versions
- **Circuit:** a single circuit with green refrigerants having precise modulation control such as EEV
- **Compressor:** Scroll compressor with variable speed feature
- **Condenser:** Air-cooled version; water cooled option as per site requirement
- **Electronically-Commutated (EC)** fan with direct-driven multiple speed plugs and step-less control for higher efficiency
- **Humidifier:** Increased Capacity to the limit of 10 kg/hr or suitable capacity depending on site requirement.
- **Heater :** Solid state heater with first response option, stage heater also can be considered as per application

Techniques to control and maintain a constant environment:

In a Laboratory, sensible load pattern is different from other Precision Air conditioning application. Generally in technological rooms i.e. data centre, telecom switch rooms, control rooms sensible heat ratio is found close to 1 (one) and that is constant; also 60~80% load of design load is there. But in this particular laboratory testing application SHR varies from 0.75 to 0.9 (based on heat load calculation) and sometimes sensible heat load goes drastically down.

Under these circumstances, it is really tough to maintain constant environment (temperature & relative humidity) in laboratory during this drastic load change with standard precision AC. During low load condition, compressor tends to switch off subjected to meet return air set point. The moment compressor switches off, it is observed in most of the cases that the internal environment gets significantly affected in terms of the tolerance on temperature (+/- 0.5C) and relative humidity (+/- 3%) not being met. This would dramatically affect the test results.

So, the challenge is to maintain constant temperature & RH during all time even in low load condition or on operating compressor & refrigerant cycle even in very low load condition.

There are two main technological attempts to serve the above mentioned purpose i.e. constant operation of compressor and its subsequent refrigeration circuit.

Hot gas bypass method (HGBP): This technology is recommended while evaporator has low load condition. It is located in between compressor discharge and evaporator inlet. HGBP provides artificial load to evaporator during lower load than design condition. Mechanically it is actually guiding the hot gas to suction of evaporator and enable compressor to run, even after meeting set point. Copper pipe with "T" junction coupled with a solenoid valve & a regulator provides hot gas bypass line arrangement. It is a purely mechanical arrangement that enables to attain part load condition in single circuit system. Constant version of Precision AC uses this mechanism to avoid frequent on-off action of fixed scroll compressor, so helps to maintain constant temperature & RH in lab area.

There are definitely pros and cons of this technology. The best part is that it offers simple structure and does not depend on electronics & controls to much; but from accuracy & extensive energy saving point of view, it has its own limitation as compared to variable compressor system.

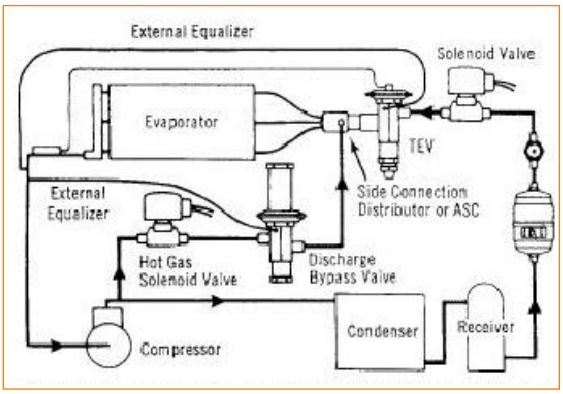

Figure 2 - Schematic layout for HGBP

Variable compressor mechanism: With the advent of technology and introduction of modern controls, electronics & variable compressor technology, nowadays uninterrupted compressor running is no longer backed by hot gas bypass line. Constant Precision AC is now equipped with inverter/digital based scroll compressor, electronic expansion valve and first responsive stage heaters. It also does have EC fan.

A team work of variable component ensures constant and minute accuracy of inside environmental parameters. Variable compressor support as low as 30% load to 100% load in infinite steps, where as electronic expansion valve helps in optimum mass flow regulation of green refrigerant & dehumidification.

A lot of electronics and controls make the system a little more complex than the legacy mechanical based ones but, in terms of performance, this mechanism serves better deliverables.

Defining industry-best standards for the Laboratory rooms

Now that we have defined the main objectives and list of components used in the testing process, we will now cover the industry standards that are in practice for the rooms in the lab. These standards include aspects such as internal conditions, Heat load calculation, Machine types, and Site Preparation. Following is a list of standards defined for the lab rooms to implement the testing process:

Internal Conditions

The temperature of the room must be around 20-23 Degree Celsius (+/- 1 Degree). The Humidity should be around 50 - 65 (+/- 3 %) RH for different applications (Refer to the table in Table 1 to see the temperature and humidity values for Paper and Tobacco).

Heat Load Calculations

Heat load is a must for all seasons (be it summer, winter, or monsoon). An appropriate unit must be selected depending on sensible and latent load. The Humidifier capacity will increase or decrease depending on that particular season. For example, considering the winter season, the Humidifier capacity will increase; therefore, the humidification requirement in the winter season must be added to the dehumidifying capacity of the coil to get the correct value.

Machine Type

- The ducted machine is located in a small plant room adjacent to the air-conditioned space. The machine has a top discharge configuration.

Pre-Installation Site Preparation

Site preparation is an essential part of the testing process. During site preparation, the following precautions and conditions need to be adhered to in order to create an optimal ecosystem for testing and quality checks.

- Avoid exposed glass as far as possible. However, if an exposed glass is unavoidable, ensure that it is minimal and heat resistant; preferably, a double glass must be used if there is no other alternative for efficient testing.
- Treat all the walls and ceilings with epoxy-based vapor barrier. Remember that the exposed roof must be insulated with vapor-barrier paint.
- Cover the floor with non-hygroscopic materials; preferably PVC tiles.
- Ensure that the AC space and plant room is airtight. No glass must be present in the plant room.
- Use air-locked double door arrangement for the Conditioned space; (a 100 * 100 supply air diffuser with no return is preferable).

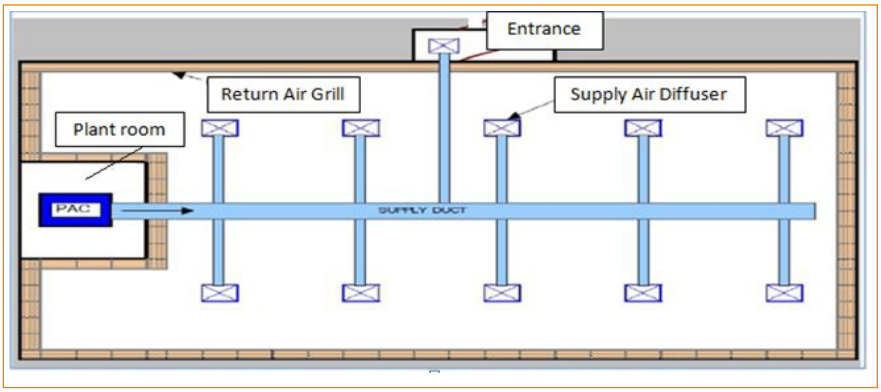

Figure 3 - Schematic layout for Site Preparation

Implementing treatment to the walls, ceiling, and floor during Site preparation

The following treatment needs to be applied to the walls, ceiling, and floor for ensuring that a site is conducive and tailored for testing.

- **Treatment for the Walls**

Use double brick walls of 115 mm thickness and an air gap of 120 mm between the two walls. Coat the layers of the walls with Coal Tar Epoxy (popular and easily available locally). The Coal Tar Epoxy will act as a vapor barrier. Use Zip plaster for the external wall. When these specifications are implemented, it results in efficient isolation for the changing ambience.

At times, the site is constructed in a different manner due to which we cannot opt for double brick walls or Coal Tar Epoxy for a vapor barrier. There is a workaround to resolve this kind of an issue. In such scenarios, Gypsum board partitions can be used to simulate the wall treatment mentioned earlier at the start of this section. However, Coal Tar Epoxy cannot be used for Gypsum board partitions. Instead of Coal Tar Epoxy, paints can be used. This implementation is not as effective as the Coal Tar Epoxy used in the preferable primary method; nevertheless, it will serve the purpose resulting in high degree of isolation during fluctuating ambient conditions.

The following list depicts the paints that can be used for good insulation:

Asian Paints:
Use the Apcodur CF641 or CF642 brand for enhanced isolation; alternatively, Epoxy Polyimide Primer Code no. 378 can also be used. One liter of Epoxy Polyimide primer needs to be used for painting an area of 6 sq meters.

Good Lass Nerolac Paints:
If Nerolac paints are being used, the Amerlock 400 brand is precisely the brand you need for enhanced isolation. Apply 2 coats of this paint followed by applying the paint-of-choice for the interiors.

Remember to use the paints on the inner side and outer side of the partition.

- **Treatment for the Ceiling**

Stretched polystyrene material (read Thermocol) needs to be used to provide insulation for the ceiling. The Polystyrene material must have 50 mm of TF quality apart from being aluminum-clad for vapor barrier protection. This prevents any kind of heat ingress from the upper floor

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- **Treatment for the Floor**
  The flooring for the lab should be done with Ceramic tiles to avoid vapor migration from below.

Points to be considered during the design stage

In this section, we will define the various things that need to be taken into consideration during the design phase. These changes make the conditions favorable for optimal testing.Following is a list of the points that are accountable for precise and accurate testing:

- Do not allow fresh air as its intake creates an imbalance in maintaining a close tolerance of relative humidity and air cleanliness. If fresh air cannot be avoided, then it has to be handled with utmost care using precautionary measures
- Restrict the supply air velocity to a maximum of 4.5 m/s. This will result in a favorable environment leading to higher accuracy in testing
- Streamline the air distribution design to allow factors such as laminar flow to be followed without any hindrance or drawbacks
- It is a good practice to place the Air conditioning unit in a separate plant room
- Choose an appropriate material while creating an air carrier after considering the form and make of the specimen. For example, if the substance of the specimen is prone to magnetic attraction, then precautionary measures should be taken on selecting that substance to prevent magnetic attraction
- Choose an appropriate degree of inclination for the air vane so that the specimen or make of the substance used should not be bogged down by factors such as excessive air pressure

Concluding note:

Quality control is set of procedure that helps review and confirms whether manufactured product adheres to a set of criteria and conforms to industry standard. Small rooms designated by Laboratory to check these qualities or a place called archives that preserve ancient & important articles need utmost care in terms of indoor environment. Energy efficient & need based product design is not only criteria, but also implementation is equally important. Right from understanding the need of application, optimum design and site preparation together create an ambient that suits for testing with extraordinary accuracy.

Source Reference:

- Preservation Advisory Centre (Environment) Author : Jane Henderson, Senior Lecturer in Conservation, Cardiff University
- ASHRAE Journal : December 2004
- Emerson Climate E-Book: Understanding Compressor Modulation
- Application Guide by Emerson Network Power : Site Preparation Guidelines on Precision Air Conditioner for Testing Laboratories


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