Humidity Control for Tropical Climate

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ABSTRACT

This paper provides an overview of the effective and practical means of humidity control for tropical climate by real experiences. Humidity control technologies have been presented for various applications. Each technology has its own merit and a good system design should include proper selection. In several cases, the integration of technologies could become the optimum choices.

INTRODUCTION

In tropical climate, which is **hot and humid**, it is an area for challenge on humidity control when 50% RH and lower is required. Tropical climate is rather unique that **humidity stays high most of the time**. Meteorological data on max, min and average relative humidity does not present **time duration**. Therefore, *there is no allowance for storage factor or the system to breathe*. One good example is on the selection of pipe insulation where the use of fiber type of insulation has high risk on condensation and closed cell insulation is safer for tropical climate.

Problems have been founded in hospitals, pharmaceutical factories, hotels, libraries, electronic factories, packaging rooms, etc. and caused serious damage to operations.

In hospital, high humidity is the cause of infection, airborne germs, odor, and mildew. Doctor are using anti-biotic against infection but this tactics could not be used for eye and bone surgery.

Humidity control enhances clean room, which normally requires low humidity.

Low humidity control is expensive and being avoided due to high investment and operating cost. However, **modern technologies are now available so that low humidity control is not that luxury anymore**.

BASIC HUMIDITY CONTROL PREPARATION

Room Pressure

Positive room pressure is crucial since infiltration will bring in humidity. Therefore, the designer should always analyze air balance on fresh air, exhaust air and leakage so that room pressure will be positive during anytime of operation.

It is advisable to have vestibule or lobby at the room entrance as airlock with the door open outward.

Fresh Air Unit

Fresh air unit has proved to be worthwhile for many installations. The unit controls room pressure and amount of fresh air more accurately according to operation and even with variation on air balance by room pressure sensor. The unit could be designed to treat outdoor air to become **neutral air** (air, which has the same temperature and humidity as the room). Therefore, the room air-conditioning system does not have to bother about the variations from outdoor conditions.

Fresh air unit has been used for better volume control and treat outdoor air to become neutral air.

Vapor Barrier

Humidity vapor could penetrate through the wall, ceiling and floor by different in vapor pressure. The greater the different in relative humidity level between inside and outside of the room, the greater in vapor pressure for humidity that try to push itself into the room. Therefore, effective vapor barrier should be part of wall, ceiling and floor.

Simple material like aluminum foil is a excellent vapor barrier but one should be cared to seal the joint between the sheets. Water- proof paint is also a good vapor barrier.

So called, cold room panel is both thermal and vapor insulation and convenient for retrofit work.

Air Distribution

Good air-distribution contributes to good humidity control and avoids dead spot. The designer should consider location of supply and return air where the supply air could have low air temperature and high relative humidity at the air diffuser.

OBSOLETE HUMIDITY CONTROL CONCEPT

Designer is normally use Psychrometric chart to select the cooling for the required conditions in order to achieve the required temperature and humidity. In comfort air-conditioning application, it is quite acceptable and simple method. However, in humidity control application, the designer should be aware of the followings:

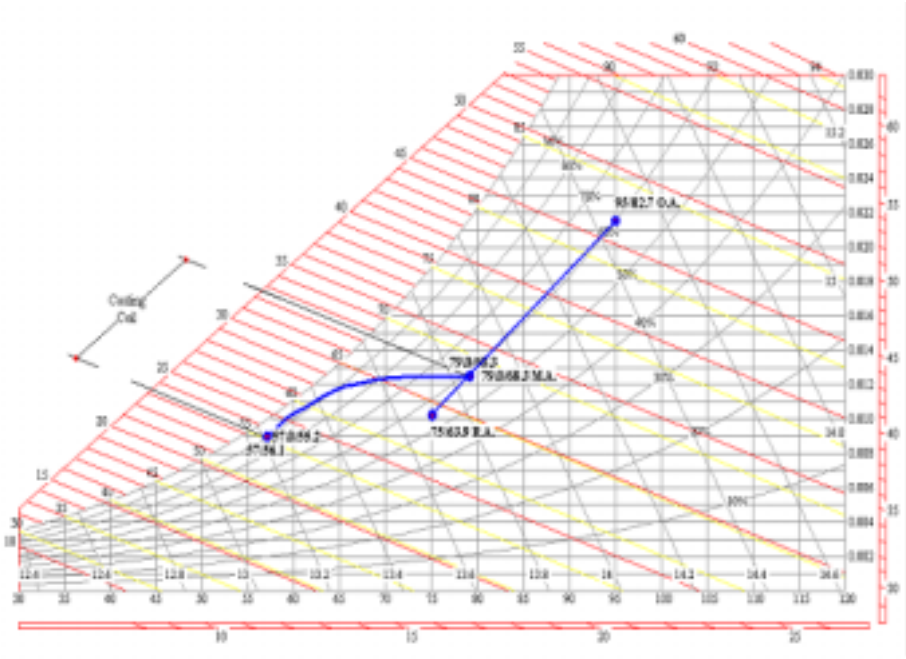
1. Most cooling coil does not perform accurately as specified.
2. There are always leaks in the air-handling unit and air duct.
3. Apparatus dew point does not stay as specified.
4. Air- flow does not stay as specified.
5. Calculation could be wrong.
6. Assumptions could be wrong.

Therefore, a good humidity control design should be more fool- proof than conventional comfort air-conditioning.

Previously, designer who has such awareness will apply **over-cooling and reheat system**. Though the system could safeguard the designer and provide the required result, but **it is an energy eater**.

HUMIDITY CONTROL FOR 55-60% RH

This is average humidity level for comfort air-conditioning. Designer could apply cooling coil selection and Psychrometric chart to accomplish this humidity level. However, to avoid humidity variation, it is advisable to follow the *Basic Humidity Control Preparation.*



Normal cooling coil performance on Psychrometric Chart

HUMIDITY CONTROL FOR 50-55% RH

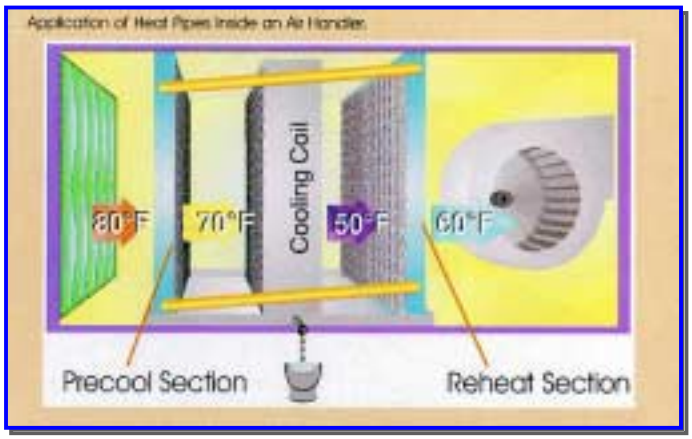
Though, designer could still apply cooling coil selection technique but he should rather be more conservative and also looking into the following measures:

1. Increase cooling coil heat transfer by higher cooling fluid velocity and/or using cooling coil with inner groove.
2. Increase air contact time by lower cooling coil face velocity such as 1.5-2 m/s.
3. More precise to minimize air bypass and leaks.
4. More precise in the selection of controls such as proper size of control valve and sensors.
5. Face bypass air-handling unit could be used for high air-changes application.
6. Very precise on cooling coil working apparatus dew point temperature.

It is also highly recommended to follow *Basic Humidity Control Preparation*. Fresh air unit becomes crucial when amount of fresh air is high as in hospital and electronic factory. Air-handling unit alone, when handle fresh air, will supply air at very low temperature (close to 10^{o}C) and has high relative humidity and cause mildew inside the supply air duct.

It is also advisable to consider applying wrap around Heat Pipe on the fresh air unit or the air-handling unit. Wrap around Heat Pipe could improve cooling coil water removal capacity by 1.5 times of the same cooling coil without Heat Pipe, with higher air supply temperature and avoid possibility of mildew inside supply air duct.

Fresh air unit with Heat Pipe has the sensible heat ratio of 0.3 – 0.4, thus, most of the cooling capacity is used to remove moisture out of the fresh air. The other benefit is the cooling capacity of the fresh air unit with heat pipe can be reduced by 15 – 20%, at the same moisture removal capacity.



Wrap- around Heat Pipe provides pre-cool and reheat function for cooling coil without any moving part or consumes energy.

HUMIDITY CONTROL FOR 45-50% RH

Humidity and temperature are tied together. Previous discussion has assumed that temperature is normal around 22-25^{o}C. Humidity control is increasingly difficult to achieve when the temperature is below 22^{o}C.

Condition in operating room of 20-21^{o}C and 50% RH or electronic factory or packaging room of 21-22^{o}C and 45%RH are example of difficult jobs.

For these jobs, it is critical to follow Basic Humidity Control Preparation and fresh air unit is highly recommended.

Wrap around Heat Pipe is a very good choice for fresh air unit. It is economical, no energy input and easy to install. Maintenance is also easy. Nothing much to worry about. However, the designer should be very precise on working apparatus dew point temperature since effectiveness of Heat Pipe depends on it. Because of energy saving promotion, hotel and shopping center chief engineers are operating chilled water system at higher supply chilled water temperature like 9-10^{o}C! This is not a good temperature for Heat Pipe and the effectiveness could drop to only 30%. One way to safeguard this problem is to have standalone fresh air unit with DX coil. Since DX cooling coil has lower temperature, Heat Pipe operates very effectively.

Fresh air unit on outdoor installation, using chilled water coil and wrap around Heat Pipe.

Standalone fresh air unit on outdoor installation using DX coil with wrap around Heat Pipe

Another alternative is desiccant type fresh air unit. However, these units are expensive and require energy input for the regeneration of desiccant. Solar energy has been used for this regeneration in order to avoid outside energy input but again adding even higher cost to the system. There are significant amount of work for the keep up and maintenance. Desiccant type unit is more suitable to be used as air to air heat exchanger as total enthalpy recovery or as Dehumidifier, when waste heat such as steam, hot air or hot water is readily available. Desiccant wheel may need replacement within 5 years in tropical climate.

Standalone fresh air unit using desiccant wheel.

Liquid desiccant with heat recovery heat pump is another good choice, since the unit is standalone and the COP could be as high as 3.5-4.

Standalone fresh air unit using liquid desiccant and heat recovery heat pump.

To install desiccant type of fresh air unit in tropical climate, it is advisable to install in a machine room. Desiccant material could absorb moisture easily even without running. Heavy rain could leak into the unit, especially when the service panel is not put back tightly in place or rain hood could not fully protect suction of rain.

HUMIDITY CONTROL BELOW 45% RH

There is lesser chance for other technology and desiccant type of cooling technology becomes prominent, especially when required room temperature is lower than 22^{o}C and humidity is 40%RH or lower. Chilled water at normal temperature and DX system could not provide low enough apparatus dew point and coil could be frozen.

Desiccant unit could be used for fresh air unit or as room dehumidifier.

Desiccant type room dehumidifier.

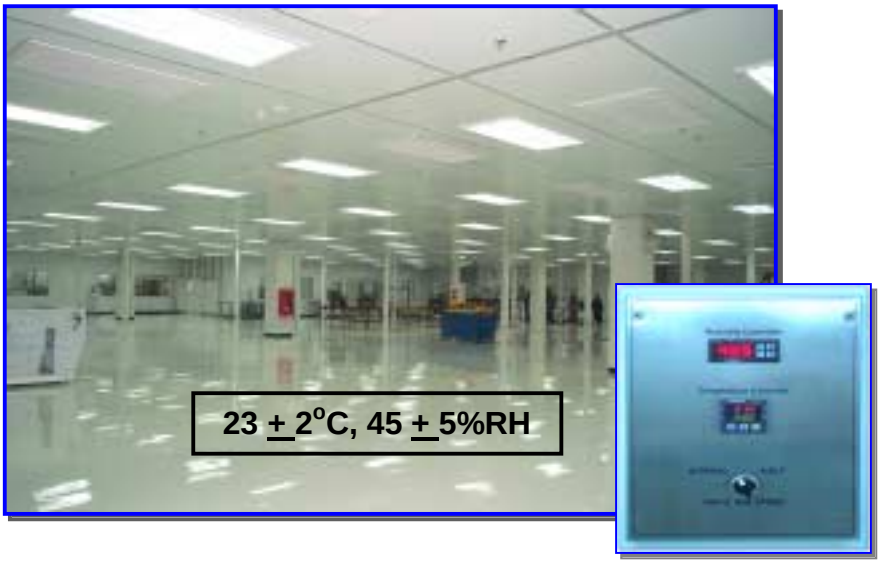
SYSTEM INSTALLATION

Humidity control installation requires experienced engineer to design and supervise. It requires very good understanding of temperature and humidity relationship, Psychrometry, and air-conditioning. Even installing dehumidifier should not be viewed as “plug and play”. Proper unit selection, location etc. are

necessary. Since several options of technology and design are available, optimum system configuration should be well investigated for best value of the money both on investment and operation. It is not necessary to go with only one technology, especially where there are different applications and variable functions.

Do not forget to allow a period of time for proper commissioning. No installation is perfect and adjustment always required. Sometime, simple air balancing means a lot. Air leaks and bypass always there. During start up, there is no load and humidity might not be achieved. Therefore, good understanding should be arranged with the owner and the engineer should be able to assure condition in real load condition.

Use grade- A sub-contractor for this work and be very professional. This is not just an air-conditioning system.



Be very professional on installation work.

SUMMARY AND DISCUSSION

Humidity control in tropical climate is something that outsider should be aware of, if he has to be involved in the design and installation of humidity control system in South East Asian countries. He could fall off the horse and drop dead easily, if he does not have enough real experience and only apply experiences from Europe or USA.

Saying this, it does not mean to scare off. In fact, if the *Basic Humidity Control Preparation* has been well taken care of, it already provide a good and solid ground for any humidity control system to be applied. On the other hand, if proper preparation is not there, any humidity control system and technology could be failed.

A good humidity control system should also be an energy efficient system.

Humidity control will certainly becomes a very important for present and future industries and will be a key of success for improving productivity.