Air conditioning for equipment and people

Precision or comfort air conditioning?

A comparative presentation

Today, air conditioning is becoming an increasingly important factor in building planning, for besides regulating the interior climate, it also contributes to the energy efficiency and operating costs of a building. Modern air conditioning technology provides a precisely tuned solution for different requirements.

Comfort (partial) air conditioning units maintain the temperature and humidity of offices and other rooms used by people within a range that people perceive as pleasant. Technical equipment rooms, on the other hand, generally require precision air conditioning, for here the task is primarily to dissipate high heat loads and maintain a precise environmental temperature and humidity.

Different technical characteristics for different goals

The requirements regarding the room condition for technical equipment and rooms used by people are vastly different. Special units have been developed in response to these different needs: precision air conditioning units for technical applications, and comfort air conditioning units for human requirements.

The influence of air temperature and humidity

Comfort air conditioning aims to provide a comfortable room condition for people, with a pleasant temperature and humidity. It is possible to define a particular range, depending on the temperature and humidity, within which the air will be perceived as pleasant by the majority of people. The higher the air temperature, the more high humidity will be felt as uncomfortable *(see Figure 1: Comfort zone)*. This demonstrates that comfort is not defined solely by the room temperature, but always by its relation to the air humidity. The great extent to which the perceived air temperature differs from the actual one with increasing humidity can be represented quite clearly by the Humidex index:

$$T_H = T + \frac{5}{9} \times \left(6.112 \times 10^{\frac{7.5 \times T}{237.7+T}} \times \frac{H}{100} - 10\right)$$

T_H … Humidex temperature (perceived temperature) in °C

T … Actual temperature in °C

H … Relative humidity in percent

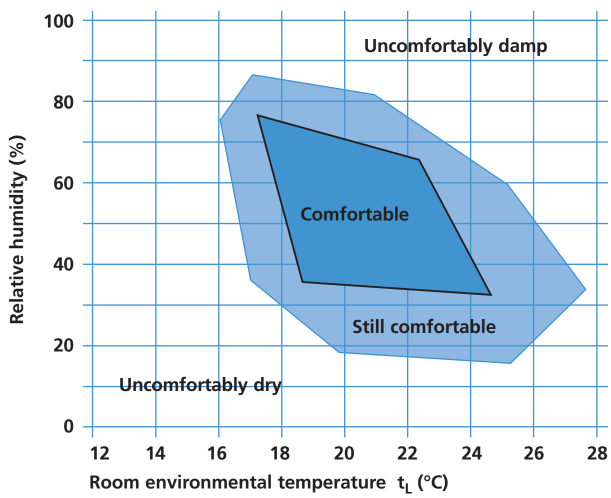

Figure 1: Comfort zone

The Humidex temperature is e.g. 28 °C at room conditions of 26 °C/40% relative humidity. If the air humidity rises to 70% while the temperature remains constant at 26 °C, the perceived temperature already jumps to 33 °C *(see Figure 2: Perceived temperature dependent on humidity)*. Therefore, in order to achieve a comfortable room condition, comfort air conditioning utilises a large proportion of its total unit capacity for the purpose of dehumidification – it dissipates heat and moisture. Comfort air conditioning units can heat and cool and provide unregulated dehumidification.

Technical applications, on the other hand, require compliance with precise room temperatures and generally air humidity within tight limits in order to

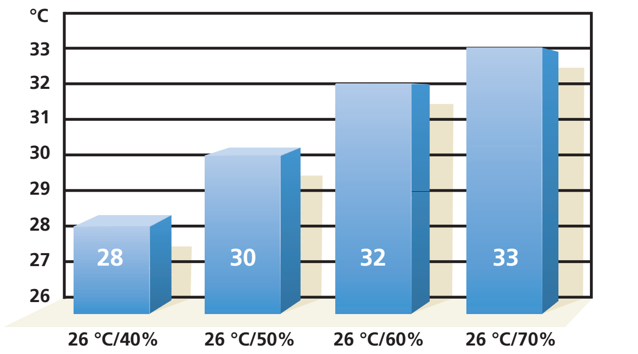

Figure 2: Perceived temperature as a function of humidity

avoid the build-up of electrostatic charge. Permitted room air conditions are described in VDI 2054, for example. Precision air conditioning units can cool and heat simultaneously, and also set an exact air humidity through controlled humidification and de-humidification. At +/- 0.5 Kelvin, the ranges of variation (hysteresis) induced by the control of a precision air conditioning unit are very small, and the relative humidity is adhered to with a variation of only +/- 3%. Naturally, the precision air conditioning unit initiates the relevant functions automatically, in order that the desired room condition can be achieved precisely *(see Figure 3: Necessary air conditioning measures to achieve a precise room air condition)*.

The influence of air volume and air speed

In technical equipment rooms, dangerous hotspots must be avoided. In order to achieve an optimum, thorough mixing of air and ensure that large heat loads can be dissipated, precision air conditioning units must circulate enormous quantities of air (up to 30,000 m³/h).

The areas available for installing air conditioning units in equipment rooms are small and expensive. In times when square meter prices are high, precision air conditioning systems have to provide maximum output with large volumes of air on the smallest possible footprint. Therefore, the outlet air speeds of up to 3 m/s are four times higher than with comfort air conditioning units.

Where comfort air conditioning is concerned, the movement of air in the room must be imperceptible, as far as possible, in order to avoid draughts. For this reason, comfort air conditioning units are optimised to create pleasant room conditions with small quantities of air (300 to 2,000 m³/h) and very low air speeds (0.2 to 0.5 m/s). Due to these low air volumes, comfort air conditioning systems generally operate with a control hysteresis of +/- 1.5 Kelvin.

The air volume and air speed have an influence on the noise level of the units – another important factor for comfort in room air conditioning. Simply put, a 6 dB(A) reduction in the noise level is perceived as a halving of the volume, regardless of the initial variable. In this way, even minor changes to the noise level achieve large effects. Modern comfort air conditioning systems operate with a noise level of 22 to 35 dB(A). Due to their technical design, precision air conditioning units produce considerably higher noise levels.

Operation and method of functioning

Precision air conditioning units have to constantly dissipate high heat loads around the clock, 365 days a year. In order to create a tailor-made, optimum climate for sensitive technical equipment, numerous parameter settings can be undertaken. The operating parameters of a precision air conditioning unit require in-depth technical understanding and specialist expertise. The requirements for comfort air conditioning, on the other hand, can vary dramatically depending on the purpose of the room, the time of day and the weather conditions. In comfort air conditioning systems, time-based changes in temperature setpoints and on-off cycles can simply be set to suit the individual.

The energy efficiency of air conditioning systems makes a large contribution to the total operating costs of a building. Modern comfort and precision air conditioning units *(see table 1)* satisfy these more exacting requirements with high COP[1] values of over 5.3.

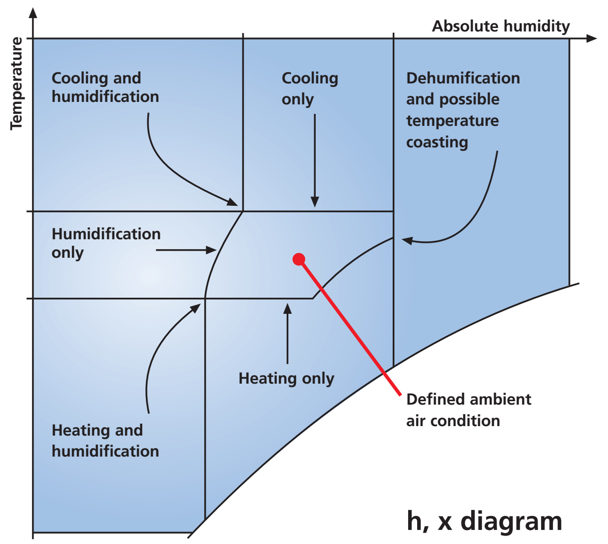

Figure 3: Necessary air conditioning measures to achieve a precise ambient air condition

[1] The Coefficient of Performance (COP) describes the ratio of (cooling) capacity to the effective power consumption of the unit.

	Precision air conditioning	Comfort air conditioning
Application	Air conditioning for technical applications	Room air conditioning for human requirements
Nominal cooling/heating capacity per individual air conditioning unit	5-150 kW (partially modular)	2-30 kW
Proportion of capacity sensible/latent	85~100% / 0~15%	50~70% / 30~50%
Control accuracy	±0.5 K / ±3 % rel. hum.	±1~2 K
Humidity regulation	Controlled humidity (e.g. to avoid electrostatic charge)	Unregulated dehumidification (for comfortable environmental cooling)
Air volume	5,000-30,000 m³/h	300-2,000 m³/h
Air outlet speed	2-3 m/s	0.2-0.5 m/s
Noise level in room	45-70 dB(A)	20-40 dB(A)
Diversity of options	Very large, due to individual production	Lower, due to mass production
Operator controls	Technical and complicated	Intuitive and simple
Method of operation	Permanent operation	Cyclical operation with time-dependent setpoint changes

Table1: A comparative overview of precision and comfort air conditioning technology

Differences in capacity and technical design

When selecting and designing precision and comfort air conditioning units, it is essential to take into consideration differences in capacity, which arise from different designs of the cooling and control technology. Below, we explain why basing the selection of a particular device solely on the nominal capacities mentioned in the catalogue is not sufficient.

Latent/sensible proportion of capacity

The total cooling capacity of an air conditioning unit consists of both latent and sensible capacity. As a rule, a cooling process removes water from the room air - it dehumidifies. The capacity required for dehumidification is referred to as latent capacity (the environmental temperature remains roughly constant). The proportion of capacity that brings about a lowering of the temperature (which must not fall below dew-point) is known as the sensible capacity *(see Figure 4: Total capacity = latent + sensible capacity)*.

As explained at the beginning, dehumidification plays a crucial role in room air conditioning. At high temperatures, it generally suffices to dehumidify the room air in order to attain environmental air conditions that are within the comfort zone. The temperature only has to be slightly reduced. The room temperature should not fall below the outside temperature by more than 5 to 7 °C, in order to prevent adverse effects on health. In order to provide the necessary dehumidifying capacity, the total capacity of a comfort air conditioning unit is divided into 30 to 50% latent and 50 to 70% sensible cooling capacity in nominal conditions. Devices designed for air conditioning in technical rooms must dissipate large heat loads at relatively constant humidity, and are therefore optimised for sensible capacity. Accordingly, the proportion of latent cooling capacity lies between only 0 and 15%, while sensible capacity is between 85 and 100% *(see Figure 5: Proportion of capacity in precision/comfort air conditioning units)*. This difference in proportion between latent and sensible capacity is one of the key differences between precision and comfort air conditioning systems.

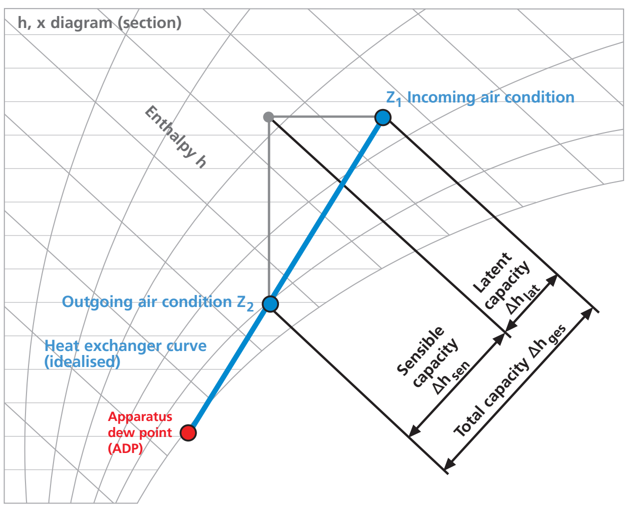

Figure 4: Total capacity = latent + sensible capacity

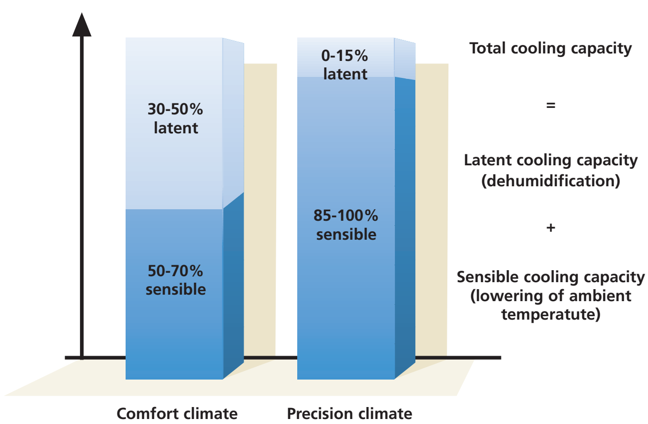

Figure 5: Proportion of capacity in precision/comfort air conditioning units

The influence of the unit's design characteristics on capacity

Air-conditioning units are designed to work in a particular temperature and humidity range for the incoming and outgoing air condition. Consequently, when designing the technical cooling characteristics of these units, a broad or narrow range is selected for the desired evaporation temperature. The resulting so-called Apparatus Dew Point ADP (surface temperature of the evaporator) depends upon the evaporator used and the air volume conveyed through the evaporator. If we combine the incoming air condition and the ADP in an h-x diagram, we obtain the idealised cooling curve, with the outgoing air condition slightly above the ADP. If we then change one of the influencing variables – the environmental temperature and/or humidity of the incoming air – the ADP may shift. This may result in serious changes in performance in terms of the unit's total cooling capacity and the ratio of latent to sensible capacity.

The design and control of the cooling circuit can influence whether the evaporation temperature (= ADP) should be maintained at a virtually constant level (i.e. subject to a lower threshold) or whether it should be variable.

Case A1: *Limited surface temperature and change in humidity at constant environmental temperature*
If the relative humidity of the air entering the unit falls whilst the temperature of the incoming air and the ADP remain constant, the proportion of latent capacity will also drop. The sensible capacity remains roughly the same. The proportion of sensible capacity in relation to total capacity becomes greater, whereas the total capacity itself drops as a result of the decreasing latent capacity *(see Figure 6: Limited surface temperature + change in humidity at constant environmental temperature)*.

Case A2: *Limited surface temperature and change in environmental temperature and humidity*
The lower the temperature of the air entering the unit (environmental temperature) whilst the ADP remains constant, the smaller the effective temperature difference at the heat exchanger. If the air flow rate through the heat exchanger remains constant, the unit's total capacity will fall. Both the latent and sensible cooling capacities of the unit decline *(see Figure 7: Limited surface temperature + change in environmental temperature and humidity)*.

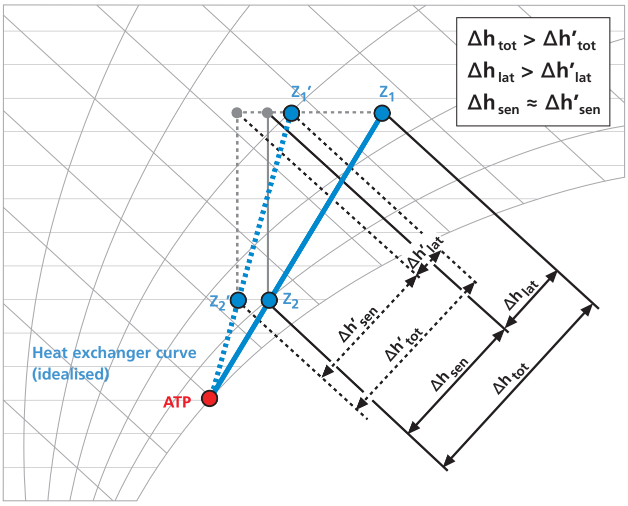

Figure 6: Limited surface temperature + change in humidity at constant ambient temperature

Case B: *Reduced surface temperature and change in environmental temperature and humidity*
If the evaporation temperature and thus the ADP is not subject to a lower threshold, it will drop when the temperature of the air entering the unit falls. The effective temperature difference at the heat exchanger remains larger compared with Case A2, but the total capacity sinks, because the cooling capacity of the evaporator drops as the evaporation temperature decreases *(Figure 8: Reduced surface temperature + change in environmental temperature and humidity)*.

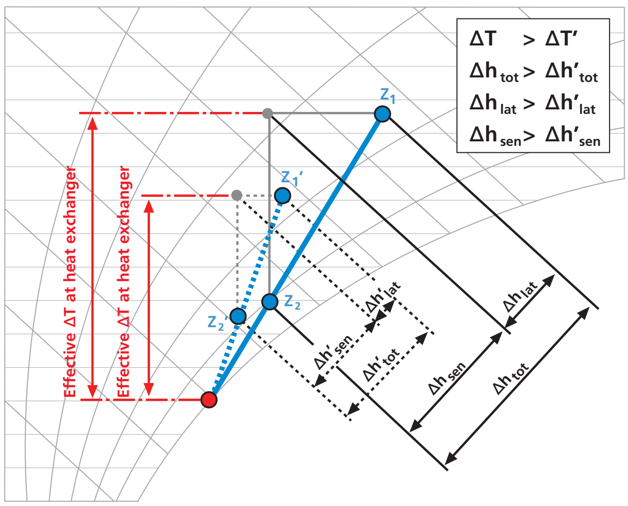

Figure 7: Limited surface temperature + change in ambient temperature and humidity

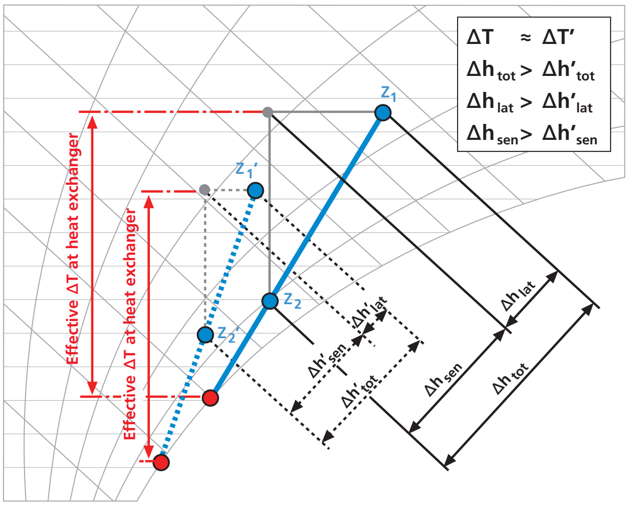

Figure 6: Limited surface temperature + change in humidity at constant ambient temperature

Differences in capacity in precision and comfort air conditioning units

If we compare air conditioning units whilst taking the technical cooling relationships explained above into consideration, we can see large differences in terms of their performance capabilities.

Precision air conditioning units must dissipate permanent, sensible heat loads at a constant room temperature. Thus, the dimensions of the air conditioning unit must be based solely on the sensible proportion of capacity. Moreover, sufficiently high air circulation must be provided for, in order to prevent the formation of hotspots in the room.

Regulated-output (inverter-controlled) comfort air conditioning units generally enforce a lower limit for the cooling-air or evaporation temperature, in order to avoid unpleasantly low air outlet temperatures.

However, this temperature limitation results in a considerable decrease in the effective temperature difference at the evaporator when the environmental temperature falls. As a result of this decrease, the effective sensible and latent cooling capacity drops.

In certain circumstances, the total capacity reaches only around 50 % of the nominal capacity at the desired operating point.

If regulated-output comfort air conditioning units are employed in technical applications, they must be dimensioned larger in accordance with the required room conditions.

Non-regulated output comfort air conditioning units (on/off) or regulated-output units with reducible ADP do not set a lower threshold for the cooling-air or evaporation temperature over a broad range. They can reach considerably lower evaporation temperatures when the environmental temperature falls. As the evaporation temperature also falls when the environmental temperature drops, the temperature difference at the heat exchanger remains greater in relation to the limited cooling-air temperature. In other words, the capacity of these devices does not fall to the same extent as it does in units with a lower threshold for the ADP, because the temperature difference at the heat exchanger remains correspondingly greater. A reduction in capacity is characterised by a lowering of evaporator cooling power as the evaporation temperature falls. These units are therefore more suitable for use in rooms with a low temperature.

The nominal conditions for the specified capacity of precision and comfort air conditioning units differ. As a rule, the catalogue specifications of precision air conditioning units are based on room air conditions of 24 °C/50% rel. hum. The nominal capacities of comfort air conditioning units, on the other hand, apply at 27 °C/48%. The table 2 below shows the differences in total capacity that can already result if performance data of comfort air conditioning units are adapted to the room air condition 24°C/50% rel. hum.

Capacity comparison of precision and comfort air conditioning systems at a room air condition of 24 °C/50% rel. hum.

	Precision air conditioning	**Comfort air conditioning**	
		ADP unlimited (e.g. on/off devices)	**ADP limited** (e.g. inverter devices)
Catalogue capacity	10.0 kW (24 °C/50%)	10.0 kW (27 °C/50%)	10.0 kW(27 °C/50%)
Total capacity	10.0 kW	9.5 kW	7.0 kW
Latent capacity	0.5 kW	3.0 kW	2.5 kW
Sensible capacity	9.5 kW	6.5 kW	4.5 kW

Table 2: Capacity comparison of precision and comfort air conditioning systems at a room air condition of 24 °C/50% rel. hum.

Summary: Only precise planning can lead to the desired goal

Room temperature and relative humidity exert a considerable influence on the performance data of partial air conditioning units with a lower threshold for the surface temperature. Units in which the surface temperature may drop to a greater extent may also be considered for use in rooms with low temperatures.

However, here too, the reduction in capacity must be taken into consideration. If an air conditioning system designed for people's comfort is subject to stringent requirements, e.g. low sound emissions, low air speeds and pleasant room conditions in relation to the outside air temperature, comfort air conditioning units must be employed. If, however, the requirements facing the air conditioning are concerned with the regulated control of relative humidity, increased control accuracy for the room temperature combined with high sensible capacity and intensive air distribution in the room, precision air conditioning units are the preferred technology.

Frequently, comfort air conditioning units are used in precision air conditioning areas because of cost. But if the operating conditions differ considerably from the nominal conditions, checking the performance capabilities of the units is crucial. People and machines require different room air climates. Decision-makers should take account of this fact by ordering the most suitable solution for the application in question – from the precision or comfort air conditioning line.

Authors

Dipl. Ing. Rainer Schmidt,
Product Manager at STULZ GmbH Klimatechnik in Hamburg, graduated in Mechanical Engineering at Chemnitz Technical University, and pursued in-depth studies in Technical Building Services at Dresden Technical University and the Technical University of Denmark in Copenhagen.

Torben Nicolaysen,
Product Manager at STULZ GmbH Klimatechnik in Hamburg, gained many years of specialist expertise as a Refrigeration System Master Engineer and Technical Plant Manager.

The authors wish to thank Dipl. Ing. Detlef Bamberger, expert in refrigeration technology and lecturer in refrigeration and air conditioning technology, for his support in the exploration of this subject.

STULZ GmbH · Holsteiner Chaussee 283 · 22457 Hamburg
Tel.: +49 (40) 55 85-0 · cool-it@stulz.com · www.stulz.com