

# Innovative Static Dew Point Cooling

**Description of the concept of air conditioning using R718 (water) as prefligerend, winning the ASERCOM Energy Efficiency Award 2004. The winners were Oxycom BV, Netherlands, and Volair BV, Netherlands jointly with Carrier Nederland. The system will be presented at ISH in Frankfurt 15. - 19. March 2005.**

■ By P.G.H. Uges,  
Volair BV the Netherlands

## Introduction

Static Dew Point Cooling is a development regarding an indirect operating air conditioning system based on the evaporation of water (R718) and suitable for moderate climates. This system consumes very little energy (up to 75% less). Temperatures below the wet bulb temperature and close to the dew point can be achieved at low cost. The system is particularly suitable to be used in large halls, showrooms, production processes etc, where a lot of sensible heat is involved, but also for cooling and ventilating of residences.

Static Dew Point Cooling can also be used a pre-cooler in order to reduce the necessary cooling capacity of a conventional system, thus saving energy, or to provide additional cooling capacity to an existing air conditioning installation.

Static Dew Point Cooling characterizes itself by low maintenance costs. This, and the low energy consumption, contributes greatly to the fact that the total running costs are considerably lower than those of a traditional air conditioning installation. The only moving part in the Static Dew Point Cooler is the fan. The system has been developed for moderate and warm climates, typical for most European countries.

The principle of evaporative cooling has been known for more than two thousand years. From times immemorial we have known that wine and water could be kept cool in unglazed stone jars. Because of „sweating“ the outside of the jar gets humid. The humidity evaporates, taking heat from the jar; even in a desert drinks can be kept cool. Later it was discov-

ered that a wet cloth in a windy window opening produces a pleasant coolness.

## Wet Bulb Cooling

When water evaporates the necessary heat is taken from the ambient air, resulting in a lower temperature. The final temperature is called Wet Bulb temperature. The temperature drop is caused by cooling the air, which supplies the heat needed for evaporation. This lasts until the air is saturated and no more water can evaporate. It is an adiabatic process resulting in a Wet Bulb temperature to be found on the saturation line in the Mollier diagram for moist air. When looking for the Wet Bulb Temperature, follow the process in the Mollier diagram to the lower right, according to  $h = \text{constant}$  (adiabatic) (KJ/Kg), until it meets the saturation line.

In the twentieth century a cooling system based on this was developed: the desert cooler.

It is made of a moist filling, an air filter and a fan. The drier the air, the deeper the cooling. It is specially used in dry (desert) climates. Nowadays it is also called Wet Bulb Cooling. Unfortunately, the evaporated humidity enters the space-to-be-cooled; the relative humidity increases greatly so that mildew may appear on walls and goods.

## Indirect Adiabatic Cooling

Because of this mildew problem, the logical next step was the development of a system based on indirect adiabatic evaporation cooling, supplied with a spraying chamber and a cross-stream heat exchanger. In this system the humidified air disappears through an outlet; the lowest possible achievable temperature is still as low as, or slightly higher than the Wet Bulb temperature. These indirect adiabatic cooling systems have been on the European market for some time now, but are not widely used because of its complexity and high costs. *Figure 1.*

## New developments

In order to be successful as a supplement to existing air condi-

tioning, an increased performance had to be developed. The running- and maintenance costs should be very low. This took a lot of time, energy, adaptations, alterations, (field)tests and thus investments. There were many questions to which solutions had to be found: how to properly moisturize the heat exchanger surface; how to control the relation of the two separate air flows; in case of a varying demand for cooling, how to adjust the cooling capacity; what material (synthetic materials, copper, aluminium) should be used?

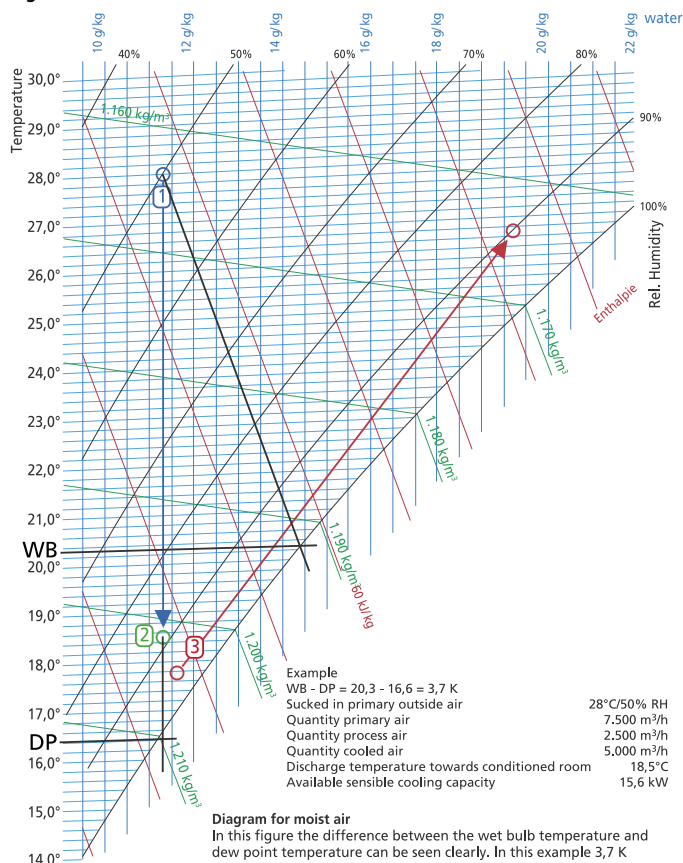
To increase the performance of the cooler, by reaching temperatures at almost dew point, a new heat exchanger has been developed. The result is a totally new concept (patent pending) of thermal conductivity, based on a hygroscopic surface which is not mechanically, or by glue connected to the heat exchanger surface, but by a water film. It makes it possible to reach outgoing air temperatures just above Dew Point.

## Dew Point Cooling

When cooling air without direct humidifying and the air-to-be-cooled is passing through a heat exchanger, no condensation will appear until the relative humidity is 100%. When this occurs, the temperature is called Dew Point temperature. In unsaturated air the Dew Point temperature is lower than the Wet Bulb temperature. But when the relative humidity is 100%, the Dew Point temperature is equal to the Wet Bulb temperature.

Dew Point Cooling implies that no condensation will occur during the cooling process, if the heat is taken „indirectly“ from the air by means of the wall of the heat exchanger. So the absolute humidity of the air-to-be-cooled remains unchanged during the cooling process. If the air is cooled until the point when condensation would occur, the Dew Point temperature is reached. For finding the Dew Point follow the Absolute Humidity line (vertical downward) (Kg/Kg) in the Mollier diagram (see figure 1.) until it meets the Saturation Damp line.

Figure 1.



YORK/ – the people to talk to

# Sabroe ChillPAC

## Packaged ammonia chillers



### ChillPAC fordele

- Fabriksbygget med den verdenskendte Sabroe stem-pelkompressor
- Standardserien omfatter drev med variabel hastighed og meget høj dellastydelse
- Oversvømmet fordampner med høj virkningsgrad både ved fuldlast og dellast
- Lille fyldning med ammoniak, som er et naturligt kølemiddel
- Ekstremt kompakt design
- Fuldsvejste varmevekslere, bukkede rør og mange indbyggede funktioner til forbedring af driftssikkerhed og pålidelighed
- Fabrikstest (FAT) sikrer problemfri opstart på pladsen
- Meget lavt tryktab i varmevekslere
- Lave energiomkostninger og minimal miljøpåvirkning

De nye Sabroe ChillPAC-aggregater er ideelle i en lang række applikationer – både inden for luftkonditionering og procesindustri

#### DENMARK

**YORK Køleteknik**  
Phone +45 86 99 44 33  
Fax +45 86 99 41 70  
www.yorkkoeteknik.dk  
york-koel@yorkref.com

#### SWEDEN

**YORK Refrigeration AB**  
Phone +46 77 164 80 00  
Fax +46 8 618 11 42  
www.yorkref.com  
info@yorkref.com

#### NORWAY

**YORK Kulde**  
Phone +47 67 17 11 00  
Fax +47 67 17 11 01  
www.york.no  
york@yorkref.no

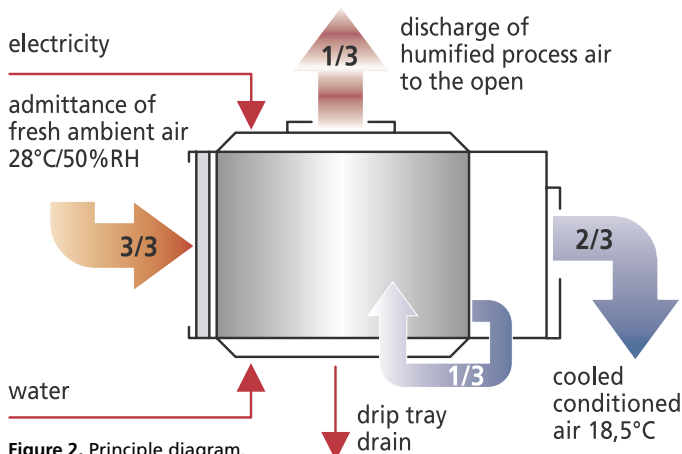


Figure 2. Principle diagram.

Recent systems are based on evaporation of water by means of a hygroscopic layer on the external cooler surface. The disengaged humidity does not enter the room to be conditioned, but disappears into the open air.

It is remarkable that these coolers produce temperatures that only recently were thought to be impossible: temperatures far below the Wet Bulb and only slightly higher than the Dew Point. This occurs, depending on the application, with an energy consumption, which is approximately 75% lower than in a conventional system.

In the explanatory Diagram (figure 2.) primary air of 28°C and 50% R.H. (11.8 gr humidity per kilogram dry air) is sucked in; this primary air is cooled down to 18,5°C. The process takes place in a heat exchanger made of synthetic material. At the end of the heat exchanger, approximately one third of this cooled air is re-routed as process air in a counter flow, along the outside of the synthetic heat exchanger plates. The outside of these plates is covered with a hygroscopic layer.

Evaporation of the existing moist in this hygroscopic layer, takes place using heat from the plate walls and thus „indirectly” from the primary air, which flows inside the plates. The primary sucked in air is thus cooled indirectly.

The amount of kJ taken from the primary air is of course equal to the amount of kJ necessary for the evaporation of the moisture. Properly moisturizing the hygroscopic layers is of the utmost importance. The process

air discharges the evaporated humidity. It is then directed into the open air and does not enter the conditioned room.

From the above and the Mollier diagram for moist air, it is clear that Dew Point Cooling as a direct system is not possible. In other words: Dew Point Cooling is always an indirect system

### Static Dew Point Cooling

The new Static Dew Point Cooler is the result of all these developments and the next logical step in looking for a less complicated design.

It is a system made of synthetic material, without a process fan, without a water collector, without a purging device and without a circulation pump; hence the name “Static Dew Point Cooler”.

### Basic assumptions for present generation of Static Dew Point Coolers

#### Choice of material

Materials should not be susceptible to corrosion. It is a known fact that sucked in air can be aggressive, even worse when in combination with humidity. Synthetic materials such as fibre glass, polyamide, neoprene, polypropylene etc. can be used in nearly all circumstances: in coastal areas, swimming pools, stables, near chemical plants, etc.

### Technical requirements and safety

- The entire system works in over-pressure.
- Fan power should be cooled away instantly, so the discharge temperature is equal to

the temperature, entering the conditioned room.

- No humidity is allowed to enter the space-to-be-cooled.
- Energy consumption should be as low as possible.
- There should be a minimum of moving parts.
- Maintenance: as little as possible.
- No Legionella risks.

**Characteristics**

- Cooling / Ventilation is possible with doors and windows open. The system functions perfectly.
- The system is applicable in places where conventional cooling is not to be realised for reasons of energy consumption.
- The system can be used in places with a weak electric power net.
- It is an excellent addition to an existing traditional cooling without sufficient cooling capacity.

**Water (R 718) as cooling medium**

The water consumption depends largely on the air quantity to-be-cooled, the absolute humidity of the sucked in air and the sensible heat to be cooled down. Under extreme circumstances it will be no more than five litres /h /1000m<sup>3</sup> cooled air. In Dew Point Cooling the hardness of water plays an important role. Usually (>3Dh), a water softener is advised. The use of soft or demineralised water together with a synthetic heat exchanger, presents no problems.

**Micro-biological aspects**

Primary air is not moisturized in the Dew Point Cooler. From a micro-biological point of view this is an advantage, because

humidity is the prominent factor for micro-biological growth. Because humidification only takes place in the secondary (process) air flow, which is directly discharged to the open air and the entire system works under overpressure, it is impossible for micro-biological contamination to occur. Furthermore it is important that no aerosols are formed with which the legionella bacterium can be transported. Due to the fact that the airspeed of the process air is low, no aerosols will occur. Moreover, the Static Cooler operates without a spraying chamber and uses no water collector. Growth of algae will not occur either because the hygroscopic layers are automatically dried as soon as the cooling process stops. *Figure 3.*

**„Static Dew Point Cooling“ should be approached differently**

- The achieved temperatures are below the Wet Bulb temperature.
- No humidity to the room to-be-conditioned; the absolute moisture of the sucked in air is equal to the absolute moisture of the conditioned air.
- Discharge of process air into the open.
- Absolute humidity determines the reached conditioned air temperature.
- Fan power is cooled down, directly after entering the cooler and does not affect the reached conditioned air temperature.
- Rising outside temperature means increasing cooling capacity
- No moving parts, apart from the fan.
- No storage of water in a water basin, so no growth of algae, no germination.
- No possible moisture leaking

towards the conditioned air; as all parts of the cooler are under overpressure towards the process air and towards the outside ambient air.

- No Legionella risks.
- 30% more sucked in air, than in a conventional cooling system.
- Depending on the system, energy savings up to 75%.
- Operational and maintenance costs are low.

**F-gasses and CO<sub>2</sub>**

Using Static Dew Point Cooling is an answer to the future European F-gasses policy and the existing CO<sub>2</sub>-policy. It makes cooling possible where this would hardly be feasible because of insufficient supply of energy.

**Summarizing**

Direct Wet Bulb cooling / Basic assumptions

- The heat necessary for evaporation is taken from processed air.
- The temperature drops until air is saturated.
- Adiabatic process (h = constant) with as final temperature: the Wet Bulb.
- Process in which absolute humidity (g/kg) increases and flows towards the conditioned room.

**Characteristics**

- Minimum realisable temperature: Wet Bulb Temperature.
- Only used for cooling down the sensible heat (no latent heat).
- Evaporating humidity enters the room-to-be-cooled, resulting in an increased absolute humidity and so a high relative humidity.
- Micro-biological growth on walls and goods in the conditioned room.
- Measures must be taken against bacteria and legionella.
- Low energy consumption.

**Dew Point Cooling / Basic assumptions**

- Air is cooled down to the point where condensation of present vapour should occur
- Temperature drops towards just above dew point.

- In un-saturated air, the dew point temperature is lower than the Wet Bulb temperature.
- Process in which absolute humidity (gr/kg) does not change.

**Characteristics**

- Moisture of hygroscopic layer evaporates; resulting in cooled process air.
- Process air cools primary air.
- Dew Point Cooler realises discharge temperatures just above dew point and below the wet bulb temperature.
- It is used to cool down sensible heat; no de-humidification.
- Moisturized process air is led into the open and not towards the conditioned room.
- No micro-biological growth on walls and goods.
- Low energy consumption.

**Static Dew Point Cooling/ Basic assumptions**

- Identical to Dew Point Cooling.
- Little maintenance.
- Simplified design.

**Particular characteristics**

- The only moving part is the fan.
- Short adjustment time at first start up.
- No Legionella risk because of:
  - indirect system with separated air flow;
  - no possible moisture leaking towards the conditioned air;
  - no spraying chambers;
  - no formation of drops, just moist air;
  - no water collector; no standing water, no algae, no germination;
  - without cooling demand, the hygroscopic layer is automatically dried.

*Volair BV does not produce air conditioning installations, but makes her knowledge and experience available for close co-operation. Volair wishes to achieve that this type of new cooling is widely marketed as an addition to existing traditional systems.*

Outside air temperature	Relative Humidity 30%	Relative Humidity 40%	Relative Humidity 50%	Outside 60%	Air 70%	
20°C	10,5°C	12,0°C	13,5°C	15,0°C	16,5°C	INDIR.DP
20°C	13,0°C	14,5°C	15,5°C	16,5°C	17,5°C	DIR.WB
25°C	13,0°C	15,0°C	16,5°C	18,5°C	20,5°C	INDIR.DP
25°C	17,0°C	18,5°C	20,0°C	21,0°C	22,0°C	DIR.WB
30°C	16,0°C	18,5°C	20,0°C	22,5°C	25,0°C	INDIR.DP
30°C	21,0°C	22,5°C	24,0°C	25,0°C	26,5°C	DIR.WB

Discharge temperatures  
 INDIR.DP = Indirect working Dew Point Cooling (data Volair)  
 DIR.NB = Direct working Wet Bulb Temperature (data from catalogue third party)

Figure 3. Discharge temperatures.