Humidity Group

of the **HEVAC** Association

Evaporative Cooling

an alternative and supplement to mechanical cooling

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1. WHAT IS EVAPORATIVE COOLING?

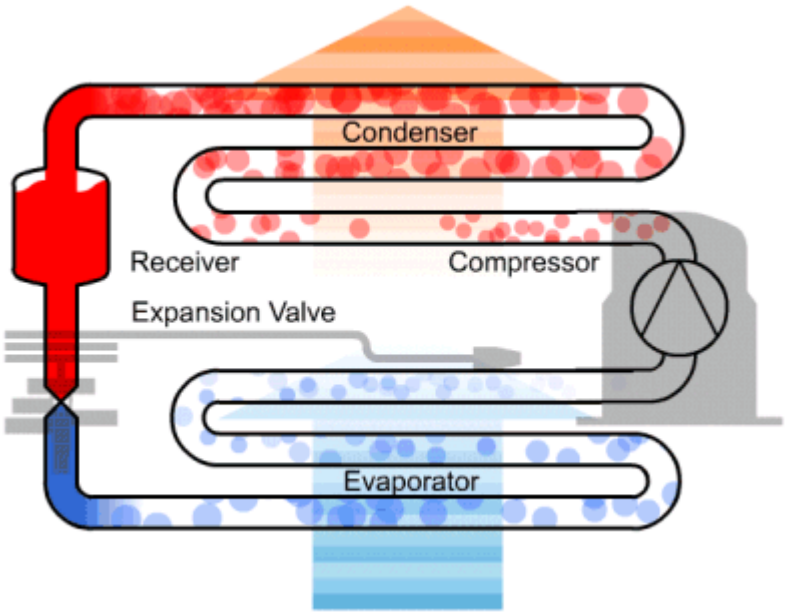
Evaporative Cooling is one of the oldest cooling systems known to man, exploiting the evaporation of water to cool the air. We have all felt the cooling effect of wet skin when standing in the wind, due to the moisture evaporating quickly on the skin, absorbing heat from our body.

A similar effect is obtained when evaporating water into the air. In order for water to evaporate and change into a gaseous state it requires energy, specifically 2257kj for 1kg of water (in comparison 419 kj is required to heat 1kg water from 0 to 100°C). In the absence of an external energy source it takes this energy from the air and as a consequence the air is cooled. This process is simply referred to as evaporative cooling or adiabatic cooling.

Every 1kg (1 Litre) of water that evaporates per hour will provide a cooling effect of approximately 680W directly to the air.

2. COMPARISON OF MECHANICAL COOLING AND EVAPORATIVE COOLING

There are various types of air conditioning systems available and this guide does not cover this topic. For the purpose of this guide when referring to mechanical cooling in its simple form, it is a system that uses mechanical work to transfer heat using refrigeration compressors similar to the diagram below.

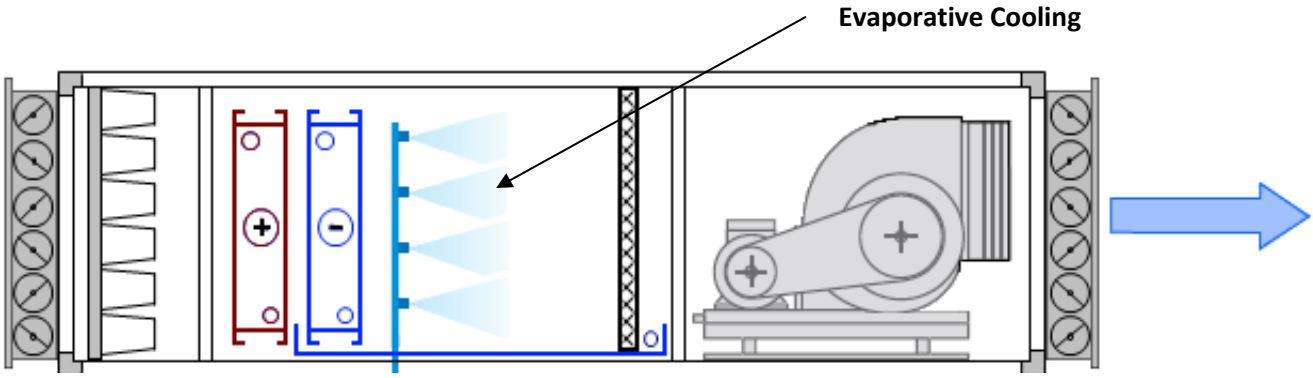


EXAMPLE OF A REFRIGERATION CYCLE

In a **Mechanical Cooling** system a refrigerant gas is pressurised using a compressor and condensed to a liquid in a heat exchanger (condenser). The refrigerant liquid under high pressure is then passed through an expansion valve which reduces the pressure and temperature of the refrigerant.

The refrigerant then evaporates through another heat exchanger (evaporator) which provides the desired cooling effect to the conditioned air. Typically, for mechanical cooling, for every kW of electrical energy used to run the system, 3 to 5 kW of cooling is produced.

Conversely, **Evaporative Cooling** uses the evaporation of water in the air to create the desired cooling effect to the conditioned air. This is done by either evaporating water over a large surface area (like wet media matrix) or by spraying the water into tiny droplets in the airstream.



Example of an Air Handling Unit incorporating Evaporative Cooling

For evaporative cooling, depending on climatic conditions, for every kW of electrical power used to run the system, between 50 to 700kW of cooling is produced.

As with the design of any cooling system, a number of factors need to be taken into account when considering the suitability of evaporative cooling technology.

Local climatic conditions, in particular the moisture content of the air, will determine how much moisture can be added to the air, and hence how much cooling can be achieved. Water usage also needs to be taken into account.

However where evaporative cooling can be incorporated into a cooling system, either as an alternative or supplement to mechanical cooling, large energy savings can be achieved.

3. INCORPORATION OF EVAPORATIVE COOLING SYSTEMS

Evaporative Cooling can be applied in two ways: -

1. Directly in the Room or Space – often referred to as ambient

When incorporated directly in the space, atomising units or evaporative media units are placed within the room, very often with built in fans to distribute the humidified and cooled air into the

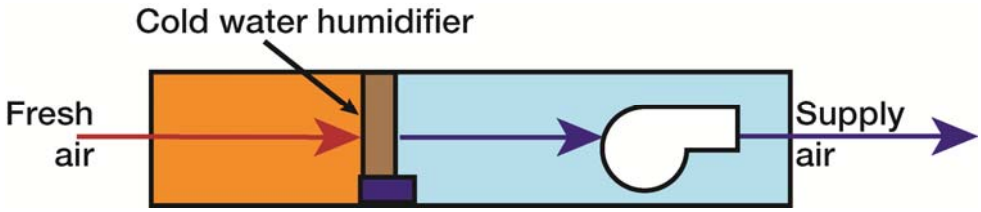
room. Normally humidity limit probes are used in the space to maintain the maximum humidity within acceptable limits of the space.

EXAMPLE OF VENTILATED ROOM ATOMISING UNIT

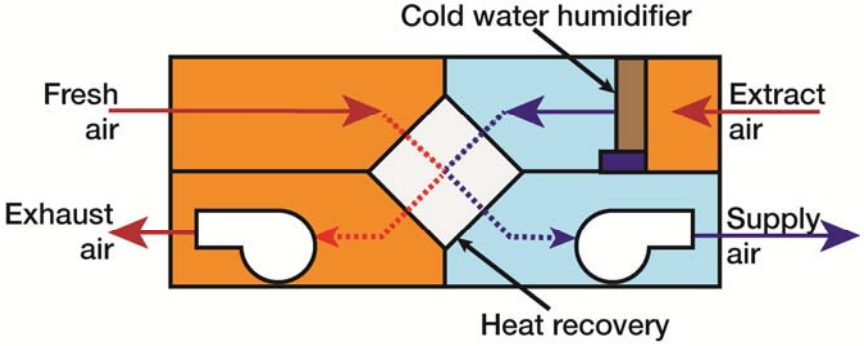
2. Inside an Air Handling Unit (AHU)

When incorporated inside an air handling unit, there are two ways in which the evaporative cooling can be used :

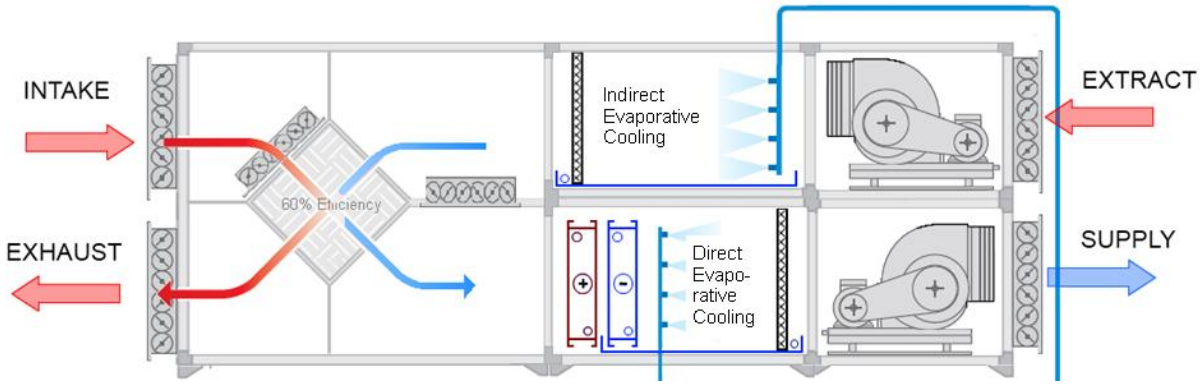
- **Direct Evaporative Cooling** is where the conditioned air is cooled and humidified by evaporating water directly in the supply airstream going to the conditioned room.



- **Indirect Evaporative Cooling** is where evaporating water cools a heat exchanger which in turn cools the conditioned air without directly adding any moisture to the airstream or the room.



In applications where the full cooling load can't be met solely by evaporative cooling, it is often possible to incorporate both mechanical and evaporative cooling within the same system.



Example of direct and indirect evaporative cooling in an AHU

4. TECHNOLOGIES

The technologies employed to create evaporative cooling focus on trying to evaporate water in the most efficient way possible. This is achieved by maximising the surface area of the water exposed to the air.

This maximising of the water surface area is undertaken in two ways, either creating small droplets of water (atomising) or spreading a layer of water over a large area.

The main types of device currently on the market, using either of the above methods are:

- **Pressurised spray**

High pressure water (10 to 80 bar) is forced through an orifice to create a fine spray

- **Compressed air and water spray**

Water at approximately 2 bar is mixed with compressed air in a nozzle to produce a fine spray

- **Spinning disc**
  Water droplets are created by directing a flow of water onto a disc spinning at around 3000rpm.

- **Ultra Sonic**
  A thin layer of water is passed over a piezoelectric transducer. Oscillation of the transducer creates tiny droplets of water.

- **Evaporative media**

Air passes over and through static panels of material that are saturated with water, which is evaporated from the wet surface.

For a full description of these devices refer to the Humidity group application guide.

5. HYGIENE

As with all hot and cold water systems, evaporative cooling devices need to comply with L8 Approved Codes of Practice. It is also recommended that the FETA Humidity Groups Code of Practice on Cold Water Humidification Systems be consulted for guidance.

Quality manufactures of adiabatic systems put into place a number of safe guards to minimise the risk of bacteria growth. These would include drain or purge cycles which ensure that water is not left stagnant in the system, inline sterilisation equipment such as Ultraviolet or silver ion, water management and good system design and use of materials to ensure that the water does not obtain warmth, nutrients and light which could encourage bacteria growth.

6. TYPICAL APPLICATIONS

Evaporative cooling can be used in many applications.

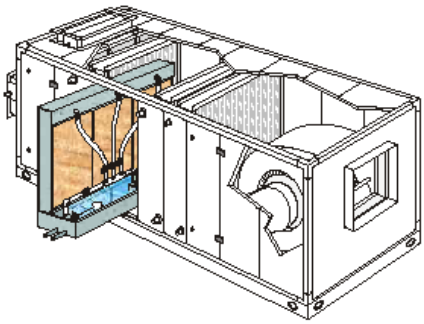
6.1. Factories

Factories where heat is generated by machinery and are open plan areas with large air volumes, employ direct evaporative cooling. Printers, textile factories, automotive plants etc are good examples of where high pressure water or compressed air and water systems introduce moisture at high level within the factory. This is generally where the warmest air is, so aiding evaporation of the moisture creating the cooling effect required. The cooler, heavier air drops down causing a flow of cool air towards the required zone to be controlled.

High level high pressure spray providing cooling within a Printing Hall

6.2. Processes

Abattoirs, cold stores, tree storage and bread retard rooms all use adiabatic direct evaporative cooling and humidification to supplement the mechanical cooling to reduce temperatures within these types of processes. Bread retard rooms cool the bread to slow the proving process, abattoirs cool the carcasses before freezing and processing and tree stores prevent growth by keeping saplings at a low temperature until required to be planted outside.



Evaporative humidifier within an Air handling unit

6.3. Commercial

Direct evaporative cooling or indirect evaporative cooling is used in commercial applications. Both require cooling in the most environmentally efficient way to comply with BREEM legislation and to reduce energy usage.

6.4. People and efficiency

Sports events and exhibition halls, chillers and gas turbines all use direct evaporative cooling to achieve the goals of cooling athletes and delegates, increasing chiller efficiency by cooling the surrounding air and increasing air density to improve turbine efficiency respectively.

Direct evaporative cooling of athletes

Exhibition hall cooling

6.5. Data Centres

Many modern data centres now use ‘free air cooling’ in conjunction with Evaporative Cooling as an alternative to traditional mechanical cooling.

Data Centre

7. TERMINOLOGY

ADIABATIC PROCESS: In thermodynamics, an adiabatic process is a conversion that occurs without input or release of heat within a system. Evaporative cooling is often described as an adiabatic process when plotted on a psychrometric chart.

AIR HANDLING UNIT: A set of modules, either pre-assembled or ‘bolted together in situ, typically including the supply and extract fans, filters, heating and cooling coils, humidifier, heat recovery unit and motorised dampers, that connects to the intake and extract ductwork to supply conditioned air and remove vitiated air.

EVAPORATIVE COOLER: An evaporative cooler is a device that cools air through the evaporation of water. Evaporative cooling differs from typical air conditioning which uses vapour - compression or absorption refrigeration cycles. Evaporative cooling works by employing water's large enthalpy of vaporization

FREE COOLING: Typically in mid season, by modulating the dampers in an AHU to provide the cooling for the supply air using cooler outdoor air, rather than the cooling coils.

HEAT RECOVERY: The term used to describe the recovery of heat from the air that would otherwise have been discharged from the ventilation system. In summer this would typically be used to reduce the dry bulb temperature by allowing the outgoing cooler discharge air to absorb some of the sensible heat from the incoming air.

OUTSIDE AIR ECONOMIZER: A system that cools a building using air from the outside environment

8. CONCLUSION

Adiabatic cooling is a process which has been around for many years. A common ancient example being fountains within Mediterranean town squares providing a cool haven from the hot summer sun. The human body also uses the evaporation of sweat from the skin to regulate body temperature in an efficient manner.

During the 1960s and 1970s air washer systems were used to provide direct evaporative cooling within air handling units of offices but with poor water management, bad design and the use of water sterilising chemicals, they created many health issues resulting from poor maintenance and were removed from use, giving the technology a bad image.

Technology, approved codes of practices, design, modern materials and the desire for low energy solutions have all contributed to making the direct or indirect adiabatic system an excellent system to be considered in this modern era.

These systems are now being incorporated into, and alongside, modern technology within air movement and climatic systems, to provide Managers of buildings and processes with a sustainable and cost effective way of providing cooling.

Published by the

HEVAC ASSOCIATION

THE FEDERATION OF ENVIRONMENTAL TRADE ASSOCIATIONS

2 Waltham Court, Milley Lane

Hare Hatch, Reading, Berks RG10 9TH

Telephone No: 0118 940 3416

Fax No: 0118 940 6258

email: info@feta.co.uk

Website: www.feta.co.uk