THE HUMIDITY GROUP VIEW ON CORRECT HUMIDITY

Ambient humidity must be neither too high nor too low to maintain healthy conditions for human occupants.

Low relative humidity can lead to respiratory problems in humans. For example, medical research shows that a number of the respiratory problems experienced during the winter months are directly linked to low RH in buildings. Epidemiological studies seem to show that occupants in buildings with medium range RH enjoy better health than those in low RH spaces.

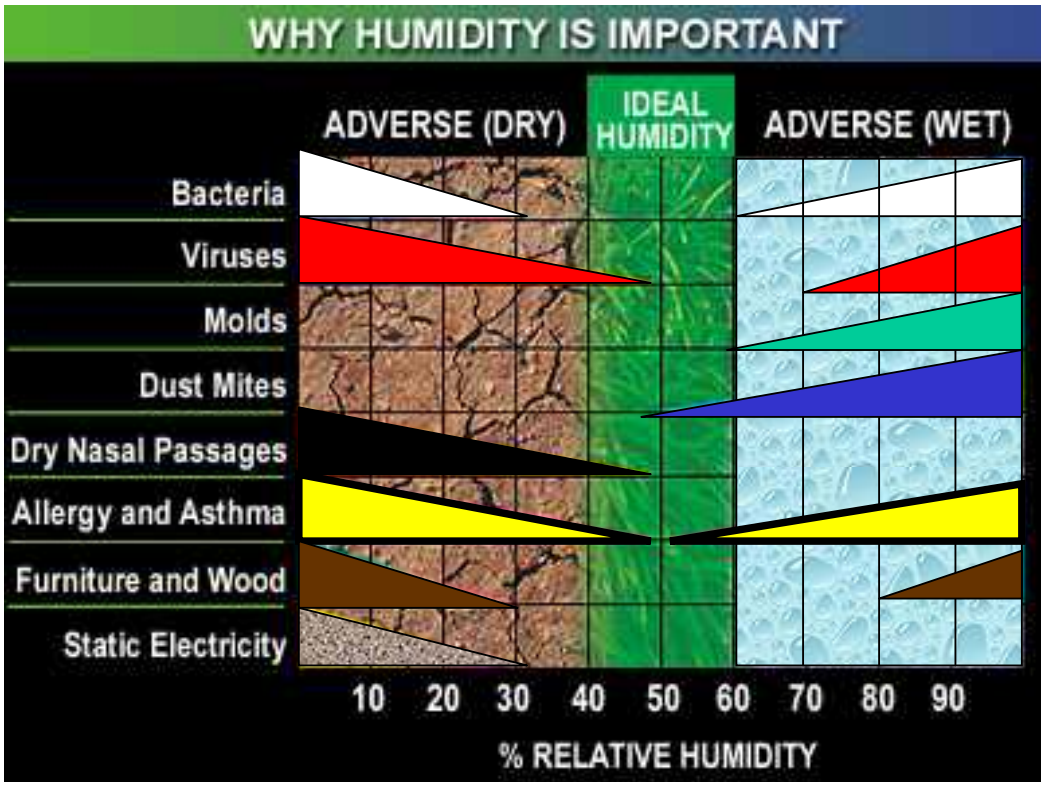
Scientists recommend 40 to 60 per cent RH – at normal room temperatures – as the healthiest conditions for humans. Bacteria growth rates and the speed at which airborne particles are transmitted are slowest in these conditions. The influenza virus, for example, loses its virulence at 50 per cent RH. Tests carried out, using both live cultures and mice, show that the flu virus lives longer at low RH levels and that high humidity can speed up the growth of allergenic organisms.

Many comfort air conditioners automatically dehumidify the air as they cool it because they rely on thermostatic control. This is why many applications rely on ac or mechanical ventilation with humidification to maintain temperatures within plus or minus 1degC of ideal and RH to within 5 per cent of target.

Office Environment

In an office where human occupants and large amounts of heat generating computer equipment work side by side, less sophisticated comfort air conditioning will remain in cooling mode for large parts of the working day and throughout most of the year. This can lead to a severe drying out of the air. Surveys show that RH below 35 per cent can add to stress levels, whereas office spaces between 40 and 60 per cent RH are classified as low stress environments.

At low RH, the air will extract moisture from any accessible source – and that means the human occupants. RH below 20 per cent has been recorded in some offices – similar to conditions you would find in the desert. This might be acceptable for camels, but is hardly conducive to healthy operation of the humans and long-term reliability of the electronic equipment.



Art collections and historical buildings/artefacts are also extremely susceptible to changes in humidity levels in the air around them. They must be protected from rapid drying out and excess moisture that encourages mould growth.

Many governments, including our own, are investing heavily in research which could lead to the eradication of super bugs such as MRSA. Early results show that humidity has a "marked effect" on the ability of such organisms to survive. Therefore, accurate control of humidity has a key role to play in the control and eventual eradication of these diseases.

Contact lens wearers, particularly hard and gas-permeable, are particularly susceptible to a dry atmosphere as the lens sits on a film of moisture on the eye. Should this dry out, the lens would feel very coarse and could eventually damage the eye.

Manufacturing

Maintaining optimum RH levels is also essential for most manufacturing environments, particularly where sensitive electronic components, textiles, wood, paper, tobacco, leather and many plastics are involved.

So-called 'hygroscopic' materials such as paper, leather, tobacco and textiles will absorb moisture if the humidity level is high, but also give up their moisture if the air is dry. They, therefore, have a direct impact on the RH of the surrounding air and this should be taken into account when calculating how much humidification an area will need.

In today's modern manufacturing environments, if the relative humidity is too high it could lead to problems with computer boards, for example, creating short circuits and intermittent hardware faults that are difficult to trace.

High RH can also encourage mould growth on colder components, but if the relative humidity is too low, it causes static accumulation resulting in discharges that can reach up to 20,000 volts and cause permanent hardware damage. RH above 40 per cent will help prevent static charge build-up, so the addition of moisture where static is present will help to prolong the expected life cycle of the equipment.

Below 35 per cent RH, there is a higher risk of static electricity discharges that can lead to fires. This is a particular concern in areas close to potential gas leaks, stores of flammable materials, airborne particles of flour, sawdust and paper or in computer data centres.

Food storage

Food storage too is absolutely dependent on close RH to maintain freshness.

Wherever fresh food crops are refrigerated after harvest or when meat carcasses require temperature reduction after slaughter, moisture loss becomes a significant cost and quality consideration.

Refrigeration of the air used for cooling removes moisture from the air, creating a cold, dry air, which increases moisture loss from fresh food. Humidifying this cold air helps minimise moisture loss by neutralising the drying effect on fresh foods.

Closely controlled humidification can also double the shelf life of meat, fish, salad and vegetables in retail display counters.

Rising standards in food quality control requirements have highlighted shortcomings in many agricultural cold stores, many of which were built some years ago. Existing direct expansion refrigeration equipment can struggle to achieve the required lower air temperatures without drying out the products. Adding humidification can allow farmers or processors to meet higher standards without the expense of having to completely replace refrigeration systems.

Raising the humidity to over 85 per cent RH greatly improves the efficiency of existing direct expansion refrigeration systems, which when fitted with effective defrost systems will not experience any problems of coils icing up, even at these high levels of humidity.

Humidity levels require close control to ensure products such as electronics and pharmaceuticals meet the correct specifications. Recommended levels are detailed below:

Comfort human conditions	40% to 60% RH
Pharmaceutical Process	35% to 50% RH
Printing areas	46% to 51% RH
Textile manufacturing	50% to 80% RH
Main frame computers / server rooms	45% to 55% RH
Hospitals	40% to 60% RH
Cellophane wrapping	45% to 65% RH

Museums	50% to 60% RH
Distilling	40% to 65% RH

How do we achieve ideal RH?

A wide range of humidification solutions are available to building services design engineers and to end users seeking to achieve these conditions. The table that follows this section details the main technologies.

However, there are two main approaches – adiabatic and isothermal.

Adiabatic humidifiers exchange the sensible heat of air with the latent heat of water leading to evaporation, which means moisture is added to the air at the expense of a drop in air temperature while the total heat (enthalpy) remains the same.

The air must be warm enough to absorb enough moisture to achieve the desired RH and this means the entering air is often preheated before humidification – this is particularly important in colder climates when a large amount of outdoor air is used. However, the temperature drop is often beneficial in otherwise warm manufacturing environments and reduces the dependence on other, more costly forms of cooling at certain times of year in office buildings. There are two main types of adiabatic humidifier: wetted/soaked media, and water atomisers/sprays.

Isothermal humidification systems use heat energy to generate steam and distribute it either in an air stream or directly into a room. The heat energy required can be provided remotely by a boiler or locally via a self-generating system.

Isothermal processes are supposed, by definition, to remain at a constant temperature, but in isothermal humidification the air temperature increases slightly because the water vapour is at or near steam temperature.

To avoid any problems with indoor air quality (IAQ) and to reduce the maintenance required for some types of humidifier, both approaches may use either demineralised or reverse osmosis (RO) feed water.

Humidifiers: Systems and benefits

Table One:

Humidification System	Applications	Advantages	Disadvantages
A1. Electric Element Steam Generators	Commercial, industrial and process industries. Typically 05-90kg/h	Flexibility with installation and location. Variable steam output. Minimum water treatment needed. Can use demineralised water to minimize maintenance.	High electrical loads. Regular maintenance/cleaning required in hard water areas.
A2. Electrode Boiler Steam Generators	Commercial, industrial and process industries. Typically 05-116kg/h	Flexibility with installation and location. Variable steam output. Will operate with “raw” water and softened water.	High electrical loads. Consumables costs can be high in hard water areas.
A3. Local Gas or Oil Fired Steam Generators	Commercial, industrial and process industries. Typically 40-200kg/h	Low running costs. Low carbon emissions. Will operate with “raw”, softened and demineralised water.	Location limited by chimney flue installation. Regular maintenance/cleaning required in hard water areas.
B1. Indirect Steam Generators	Commercial, industrial and process industries, plus hospitals and pharmaceuticals sites. Typical 100-1000kg/h	Utilises existing site steam or hot water resources. Flexibility with installation and location. Will operate with “raw”, softened and demineralised water. Ideal for “pure” steam applications.	Heat exchange efficiency can be poor, e.g. <75%, in the heat exchanger. Distribution losses of the high pressure steam or high temperature hot water can result in an overall efficiency of only 50%.
C1, C2 & C3 Cold Water Atomisers	Medium to large scale commercial, industrial and process industries, plus horticultural sites.	Low running costs. Low carbon emissions. Large capacities available. Variable output – close control.	Water quality monitoring and recording regime required. Reverse osmosis water treatment may be required in hard water areas.

	Typically 50-1000kg/h	"Free" adiabatic cooling available, resulting in a net reduction in carbon emissions.	
C4. Ultrasonic Humidifiers	Small to medium scale commercial, industrial and process industries. Plus food preparation and cold storage applications. Typically 1.5-50kg/h	Low running costs. Low carbon emissions. Very small droplet sizes. Stepped and modulating output and fast response gives good close control. "Free" adiabatic cooling available, resulting in a net reduction in carbon emissions.	Water quality monitoring and recording regime required. Demineralised water recommended and necessary in hard water areas.
D1. Wetted Media Humidifiers	All commercial, industrial and process applications with centralised air handling plant. Typically 10-900kg/h	Low running costs. Low carbon emissions. Simple and reliable design. "Free" adiabatic cooling available, resulting in a net reduction in carbon emissions.	Water treatment might be required in hard water areas. Water quality monitoring and recording required. Requires air filtration prior to humidifier.

Running costs

Reduced running costs and improved water conservation are now key considerations for most end users, but specifying engineers can argue that mechanical humidification will contribute positively to sustainability. Where it might have been left out as a cost saving measure in the past, it is now being regarded as a 'must-have' to reduce overall running costs and improve environmental comfort.

However, the increasing focus on both capital and lifecycle costs means specifiers have to arrive at a keenly priced, but well designed solution that does not add to the carbon footprint of the project.

Adiabatic humidifiers, for example, are regaining popularity despite some residual concerns about their susceptibility to the potential build-up of Legionella bacteria in standing water. Modern systems have effectively addressed this long-standing area of concern making this low running cost technology a popular choice again, particularly as it offers a bonus of 'free cooling' from the water evaporation process.

Many modern systems have effective built-in protection against the potential hazard of bacteria growing in standing water and its transmission into the air via evaporation. The efficiency of the water vaporisation system is an important consideration when seeking to design a system that will not allow potentially hazardous pools of water to collect.

For example, with distributed water systems that serve large parts of a building, a centrally controlled high pressure system feeding atomising nozzles or wetted media are popular solutions.

Control strategies for humidification are now highly sophisticated so that, rather than having to run the whole system the needs of individual spaces can be precisely addressed.

Applications – choosing the right system

	Humidifier within the duct or AHU														Direct to the room									
	Adiabatic									Isothermal					Adiabatic							Isothermal		
	Adiabatic Air Washers.	Wetted media with water re-circ	Wetted media without re-circ	Rotating drum	Centrifugal with horizontal axis	Ultrasonic	High-pressure water atomisers	Pressurised water atomisers	Compressed air atomisers	Centralised steam	With steam - water exchanger	Infrared	Fuel fired - GAS	Immersed electrode	Electric heater - Resistive	Wetted Media with Water IRe-Cir	Rotating drum with fan	Centrifugal with tank	Ultrasonic	High-pressure water atomisers	Pressurised water atomisers	Compressed air atomisers	Fuel fired - GAS	Immersed electrode	Electric heater - Resistive
Hospital environments																								
Sterile env (operating theatres etc)										V	V		V	V	V									
Clinics and corridors						V	V	V	*	V	V		V	V	V	V				V					
Radiology, CAT and magnetic resonance						V				V	V		V	V	V	V								V	V
Laboratories						V				V	V		V	V	V									V	V
Service Compartments																								
Data processing centres	V	V	V			V								V	V	V			V					V	V
Measuring laboratories						V	V	V	*					V	V	V			V					V	V
Clean rooms						V		V	*				V	V	V				V						
Switchboard compartments						V							V	V	V	V			V						
Engine rooms	V	V	V		V	V	V	V	V	V	V		V	V	V	V			V	V					
On stand-alone A/C units																								
Fan coils						V								V											
Roof-top units										V	V		V	V	V										
Precision air conditioners						V						V		V	V										
Civil environments																								
Offices	V	V	V	V	V	V	V	V	V	V	V		V	V	V	V	V		V	V				V	V
Commercial premises (shops / stores)	V	V	V		V	V	V	V	V	V	V		V		V	V	V		V	V				V	V
Public premises (restaurants/bars/discos)	V	V	V		V	V	V	V	V	V	V		V	V	V	V	V		V	V				V	V
Large atria (malls/hotels/airports)	V	V	V		V		V	V	V				V	V	V	V				V	V	V			
Museums, galleries, archives, libraries			V	V		V	V	V	*	V	V		V	V	V	V	V		V	V				V	V
Schools and Universities	V	V	V	V	V	V	V	V	V	V	V		V	V	V	V	V		V	V				V	V
Amusement parks (effects)																			V	V	V	V			
Steam rooms / spas													V	V	V								V	V	V
Industrial facilities																								
Timber seasoning stores		V	V				V	V	V	V			V					V		V	V	V	V		
Word-working facilities		V	V				V	V	V	V			V					V		V	V	V	V		
Textile workshops		V	V				V	V	V	V			V	V	V	V		V		V	V	V	V	V	V
Paper stores		V	V				V	V	V	V			V	V	V	V		V		V	V	V	V	V	V
Printing facilities		V	V				V	V	V	V			V	V	V	V		V		V	V	V	V	V	V
Plastic moulding workshops		V	V				V	V	V	V			V	V	V	V		V		V	V	V	V	V	V
Leather and hide processing and stores		V	V				V			V	V		V	V	V	V			V	V			V	V	V
Photographic laboratories		V	V										V	V	V	V							V	V	V
Electronic industry		V	V				V								V	V				V					
Food industry																								
Meat and fish processing		V	V			V	V	V	*									*	V	V	V	*			
Bread rising						V	V						V	V	V	V			V	V			V	V	V
Cheese Maturing		V	V			V	V	V	*				V	V	V			*	V	V	V	*	V	V	V
Wine ageing cellars		V	V			V	V	V					V	V	V	V		V	V	V	V	V	V	V	V
Cold rooms		V	V			V	V									V		*	V	V	V	*			
Retail Display Cabinets																			V		V				
Hatcheries							V									V				V					
Malting industry							V									V				V					
Zoology and Agriculture																								
Livestock farms	V	V	V				V	V	V							V		V		V	V	V			
Glasshouses	V	V	V		V		V	V	V							V		V		V	V	V			
Fruit and veg conservation	V	V	V		V		V									V		V	V	V	V	V			
Mushroom cultivation	V	V	V		V		V									V		V		V	V	V	V	V	V
Tobacco seasoning	V	V	V		V		V			V	V		V	V	V	V		V		V	V	V	V	V	V

* = Use demineralised water only

Installation, Commissioning, Service and Maintenance

Humidifiers present particular installation and commissioning challenges as they can comprise water, water treatment, electrical power, gas, compressed air, steam distribution, sprays, control signal, air flow and drainage.

All of these elements must be installed and commissioned correctly, and be accessible for regular and essential maintenance throughout the lifecycle of the system.

The diversity of types of humidifier and the range of services required means that many specifiers and contractors are unfamiliar with all aspects of their installation, commissioning, operational and maintenance requirements. It is therefore advisable to establish a good working relationship with the humidifier supplier at all stages of implementation from design and right throughout the working life of the humidifiers concerned.

Installation

Installation of humidifiers should always be done in accordance with the manufacturers' installation manuals. It should be carried out only by suitably qualified technicians, including plumbers and electricians, and be in accordance with local legislation and byelaws including those relating to connection to the mains water supply, power supplies and regulations relating to the control of Legionnaires' disease.

It is always worth seeking the advice of the manufacturer / supplier on installation at the design stage as a wrongly installed humidifier might not operate properly. For example, poorly installed steam distribution can lead to reduced steam output; incorrect condensate drainage might lead to premature wear of electrodes in electrode-boiler humidifiers; and pipe work dead-legs can pose serious health risks by encouraging the growth and proliferation of microbes in cold water humidifiers.

Whilst humidifiers, generally, present a low risk of Legionnaires' disease, failure to install and maintain a humidifier in accordance with the manufacturer's instructions can lead to contamination – *see earlier section.* If they are installed in difficult to access areas, they may suffer from lack of maintenance leading to reduced output and potential health hazards.

Humidifiers form part of the water system in a building and should be included in the risk assessment for the water system as a whole, and be part of the Legionella monitoring and control regime. This corresponds with the Health and Safety Commission's Approved Code of Practice, L8, '*The Control of Legionella Bacteria in Water Systems*'.

Commissioning

Commissioning of humidifiers, as with most hvacr plant, should only be carried out by suitably

trained and experienced staff and in accordance with the manufacturers' recommendations. It is often advisable, due to the diversity and complexity referred to earlier, to have commissioning carried out by the product supplier.

Commissioning engineers regularly find that the water supply is not available and/or controls are not connected. Some have even arrived on site to find the humidifier still in its box. Pre-commissioning checks should therefore be carried out to ensure that the installation has been completed correctly and that appropriate services to and from the humidifier are available so commissioning can actually be carried out.

Where the humidifier feeds an air handling system, the AHU should be accessible to the commissioning technicians and provision to turn off the AHU may be required.

In situations where there is a dispute over performance, this is commonly resolved by working closely with the controls company, so it is useful to have a competent representative from the controls company available at the time of commissioning.

Any reputable commissioning company will provide a full commissioning report, including a report on snags that might impact on performance in the future.

Maintenance

The threat of scale formation and microbial contamination are of particular concern with humidifiers, so regular maintenance to ensure their consistent and safe performance is essential. Failure to maintain them can result in reduced output, higher energy costs, shortened humidifier life, poor control of humidity levels and health risks.

Manufacturers' instruction manuals provide guidance on performance checks, maintenance schedules, cleaning, de-scaling and disinfection requirements, and guidance for the appointed person on monitoring and control of Legionnaire's disease. Steam humidifiers, generally, represent a lower risk than cold water systems, but L8 insists that humidifiers, which generate an aerosol, must be tested for Legionella every six months. In certain applications, such as food retailers, manufacturers recommend the same water is also tested for E.Coli and other coliform bacteria.

The frequency and type of maintenance must take into account the safe working life of the system's components such as electrodes, cylinders, UV lamps, filters, electrical components, membranes, nozzles, etc. the maintenance schedule proposed in the building operator's O&M manual should be reviewed in the light of a risk assessment of specific humidification issues.

Many humidifiers require that major components, such as the boilers/cylinders in electrode-boiler humidifiers, are regularly replaced. Reputable suppliers maintain a stock of such service spares as a matter of course, but it is advisable to keep a stock of regularly used items on site.

The maximum recommended period between cleaning and disinfection should be no less than six months, but is contingent on competent risk assessment of the water system as a whole, the application itself and the results of subsequent water testing.

Well-designed humidification systems will incorporate design features such as automated drain down and pipe-work purges, no dead legs, antimicrobial water treatment etc. However, where

these elements are absent or where water or ambient temperatures exceed 20°C, the risk of Legionella contamination is greater and this should be reflected in the risk assessment, with more frequent monitoring and control advised.

Humidifier maintenance schedules should be documented and records kept, as a matter of good practice – and for monitoring and control of Legionnaires' disease it is required. This should include details of the statutory duty holder, the risk assessment of the systems concerned, and who is responsible for maintenance, as well as water sampling frequency, tests and results, routine maintenance, cleaning and disinfection dates and details. Only competent persons, as defined in L8, should be used to repair, maintain, clean and disinfect humidification systems.

Full details of these requirements can be found in the HSE's ACoP L8.

Humidifier operation is, typically, seasonal and maintenance requirements vary according to the time of year. During extended periods when humidifiers are out of use, they might require decommissioning to ensure that water does not stagnate within pipe-work, and re-commissioning prior to the heating season.

Humidifiers are often the most complex aspect of an air handling system. In view of this, with boiling water, steam, potentially contaminated water, varying demand, seasonal decommissioning, electricity, plumbing and controls, where the installer or user opts to maintain the equipment themselves or subcontracts the job to a third party, it is important that those carrying out the maintenance are suitably trained. The manufacturer or supplier is often the most appropriate organisation to carry out maintenance for this reason. Service contracts will be tailored to meet the site's specific requirements, according to the importance of humidification in that situation, hours of use, the quality of the water supply, their pattern of use and the degree to which the client wants to be involved in the maintenance schedule.

A reputable supplier of humidification systems will always try to ensure that users have suitable maintenance agreements in place. They also try to ensure that users are fully aware of the requirements for service and maintenance and that a suitably trained person is responsible for routine maintenance.

A proper maintenance schedule will ensure consistent humidifier performance, avoid the need for costly repairs and get the best return for the client's investment.

Conclusion

Building services projects have always suffered from the ‘lowest first cost’ syndrome and humidification has often been a ‘cost victim’ when engineers are put under pressure to find savings.

Yet, correct humidity control has a vital role to play in almost every type of building. It has direct impact on the health of building occupants, the longevity of computer and IT equipment, the quality of manufactured goods, the shelf-life of food products and the condition of historical artefacts.

Retrofitting humidification later is the expensive option, but often the building operator is left with no choice when the damage caused by poor RH control becomes evident. However, it is far better to assess the project properly at the outset and make sure the client gets the benefit and the peace of mind from Day One.