



10-POINT GUIDE TO IMPROVING TEA FERMENTATION WITH HUMIDIFICATION

Humidification and Evaporative Cooling



PROPER HUMIDIFICATION IMPROVES FERMENTATION



Oxidation is the process that creates the theaflavins and thearubigins in tea that give the finished product its taste, strength and colour. It is an essential stage in the production of some teas, such as black and Oolong, and avoided in others, such as green and yellow teas.

The chemical process of oxidation starts during withering and continues to varying degrees throughout the tea's subsequent stages of production. The main stage concerned with developing the tea's characteristics through oxidation occurs in the fermentation area. It is here that the environment is managed to control the oxidation process through ventilation, temperature and humidity control.

These factors combine with the exposure to the air of the oxidising tea leaves, or dhool as it is referred to, that largely determine the tea's final characteristics.

The moisture level in a withered leaf has a direct impact on the oxidation process, as moisture acts as a catalyst for the chemical reaction. So any reduction in the dhool's moisture level through air drying will inhibit oxidation and affect the liquor and quality of the tea. This results in a lower market value and a less profitable tea factory.

Therefore, the objective of humidity control in a tea fermentation room is to prevent moisture loss from the dhool by maintaining a state of moisture equilibrium between air and tea.

Improving the way humidity is managed is a quick and reliable way to enhance a tea factory's productivity but getting it right is not easy. The humidity level needed is an extreme environment that cannot be consistently maintained without specialist equipment and expert knowledge.

By following this 10-point guide to tea factory humidification, you will be able to enhance your fermentation room's atmosphere and achieve a more optimum humidity for improved productivity.

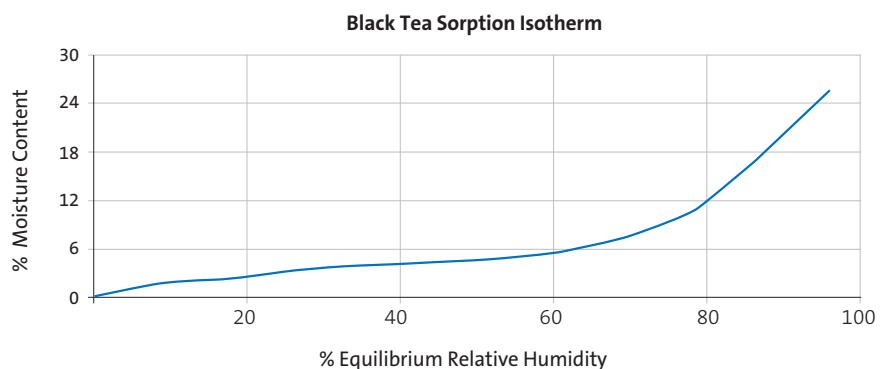
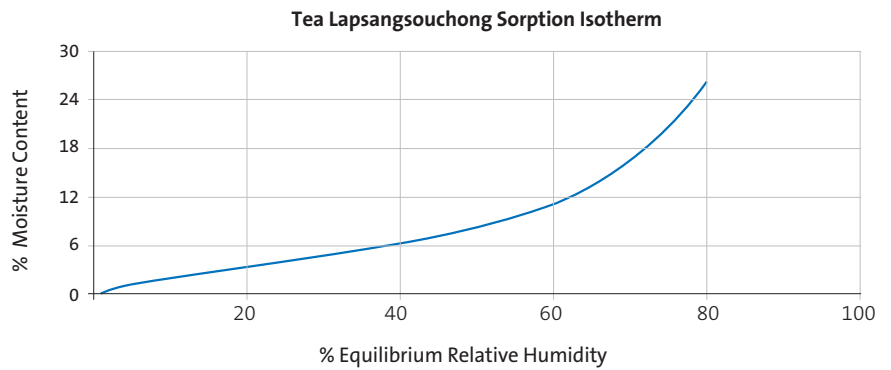
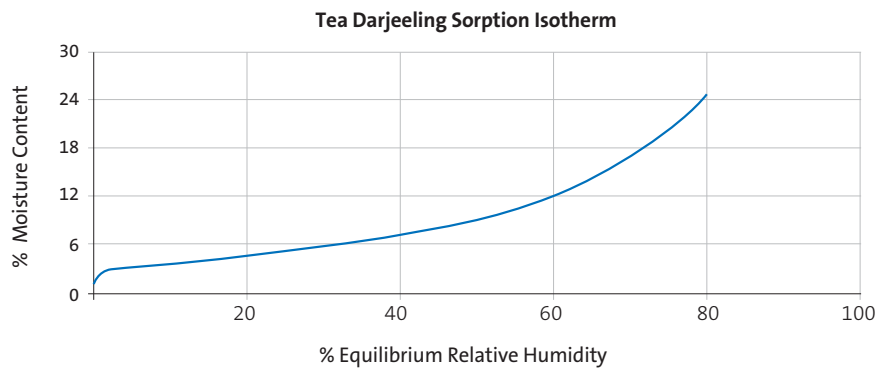
The optimum level for a tea fermentation room is typically between 95-98% relative humidity.

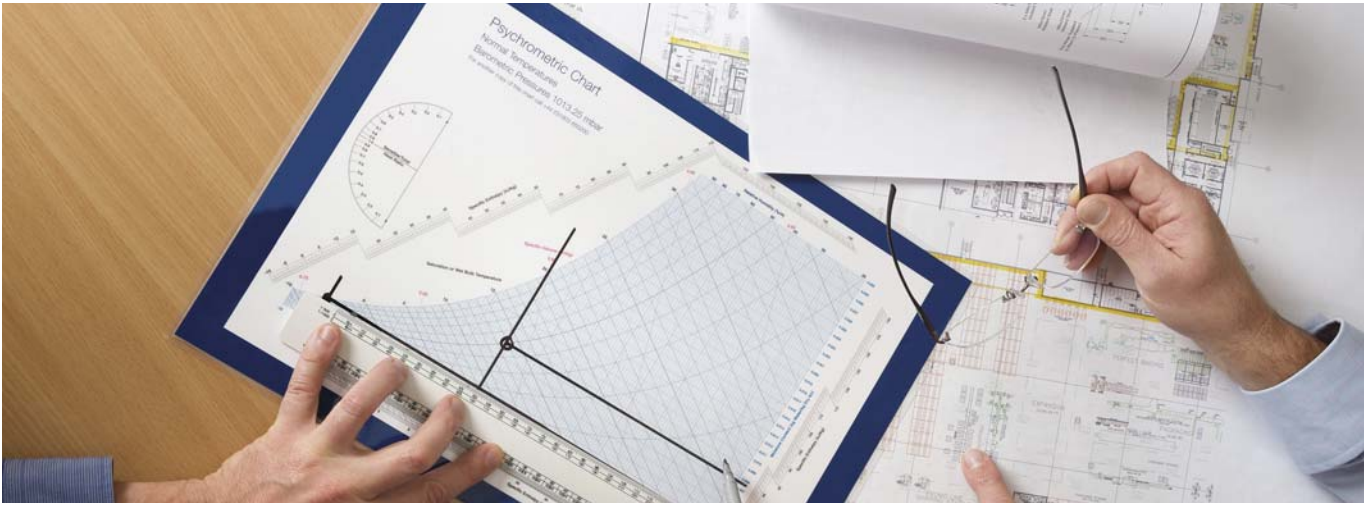
However, the ideal humidity of the room air to prevent moisture loss from the tea leaves is dependent on the specific moisture content of the tea itself. If the tea has low moisture content, then lower air humidity will

be sufficient to maintain the moisture equilibrium between tea and air. Once you know the moisture content of the tea a sorption isotherm graph can be used to calculate the air humidity required. This is a curved line graph that shows for any given tea moisture content what the corresponding air humidity ought to be for perfect equilibrium.

Tea passing through a fermentation area that is correctly humidified should not experience any weight loss. If it does then the ideal humidity level is not being maintained, moisture is being drawn from the dhoor by the air and the tea's final quality is suffering as the oxidation process is being impaired.

Example sorption isotherm graphs at 10°C





Once the ideal level of air humidity has been understood, the volume of moisture required to maintain this humidity level will need to be calculated, given the fermentation room's specific characteristics. This volume of moisture is typically expressed in kilograms per hour and is referred to as the "humidity load".

In order to calculate a fermentation room's humidity load the following parameters need to be noted:

- The desired humidity level (see point 1)
- The air volume of the room (room height x width x length)
- The temperature of the room
- The temperature of the outside air
- The humidity of the outside air
- The number of air exchanges the room experiences per hour

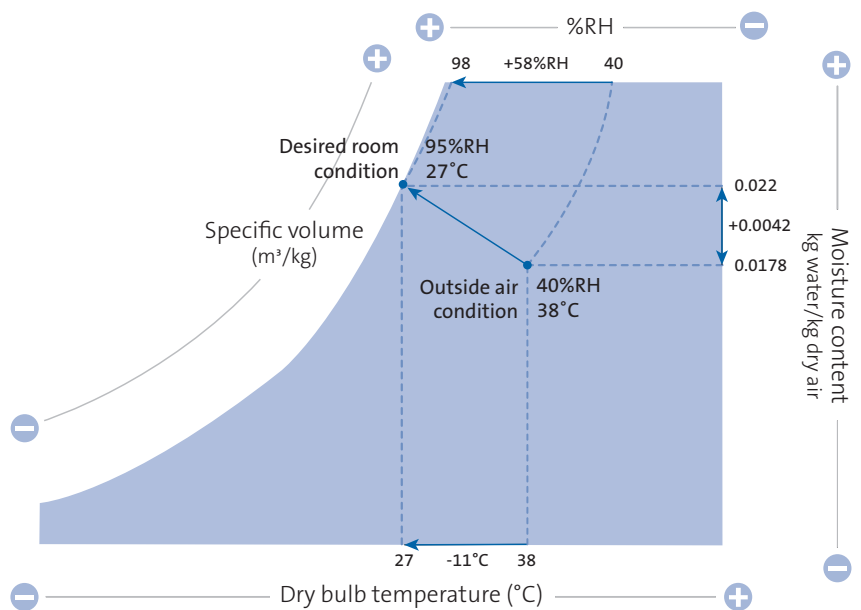
By plotting the internal and external air conditions on a psychrometric chart, the volume of moisture needed per

kilogram of dry air can be determined along with the specific volume in m^3/kg .

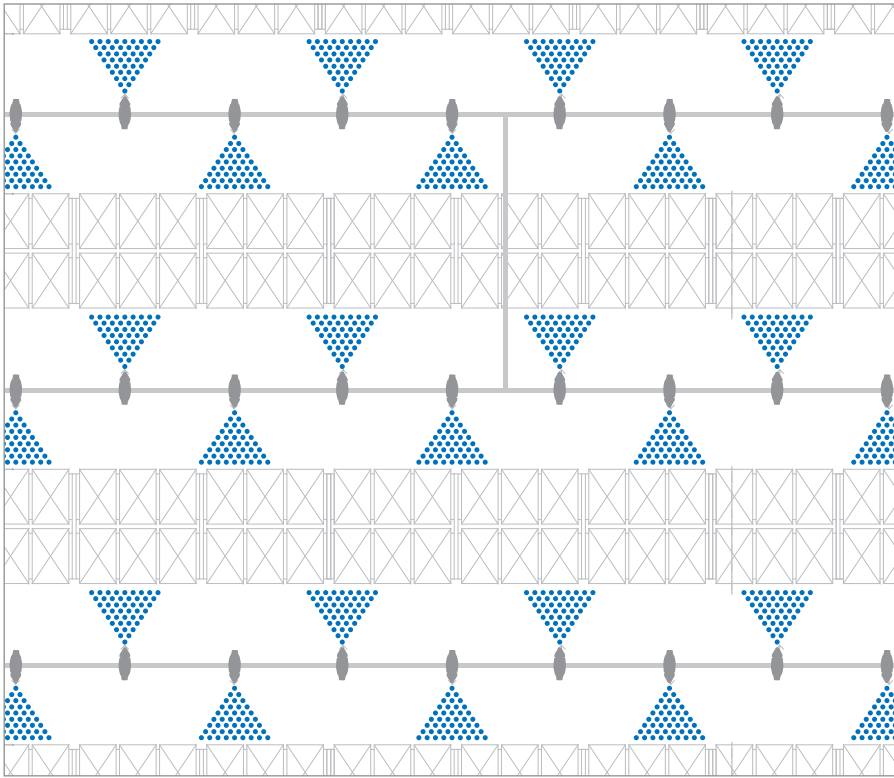
The following equation is then used to calculate the required humidity load for the room.

$$\frac{\text{Moisture x air vol x no. of air changes}}{\text{Specific volume}} = \text{Humidity load}$$

To ensure the humidification system is capable of meeting the needs of the factory throughout the year, the internal and external air conditions should be based on the hottest and driest times. If the humidifier is undersized it won't be capable of maintaining the necessary air humidity and moisture will be drawn from the tea, impairing the oxidation process.



Example psychrometric calculation



Example nozzle layout diagram with uniform room humidification



It is vital to achieve the required humidity level evenly across the room. Any areas of the room experiencing low humidity will reduce oxidation of the tea in those areas and detrimentally affect the development of the tea's characteristics.

In order to achieve even humidity throughout the fermentation area, the moisture must be introduced at multiple points rather than from just a

few or even just one central distribution point. A single "spot" humidifier is often used in tea factories but cannot accurately maintain even room humidity as it relies on the air movement to distribute the moisture.

The ideal number of humidifier points will depend on the capacity of each and the overall required humidity load.

Varying the quantity of moisture introduced at the different points of injection, given the room's specific characteristics, can also help produce a more even moisture distribution. For example, it is important to introduce a greater quantity of moisture close to the where dry air enters the room and avoid over humidifying areas near to the points from where the air is extracted or exhausted (see section 6 on Ventilation).

HUMIDIFIER CONTROL AND HUMIDITY LEVEL ACCURACY



The ideal level of humidity required in a tea fermentation area is an extremely high humidity condition and it's important to maintain it accurately and consistently.

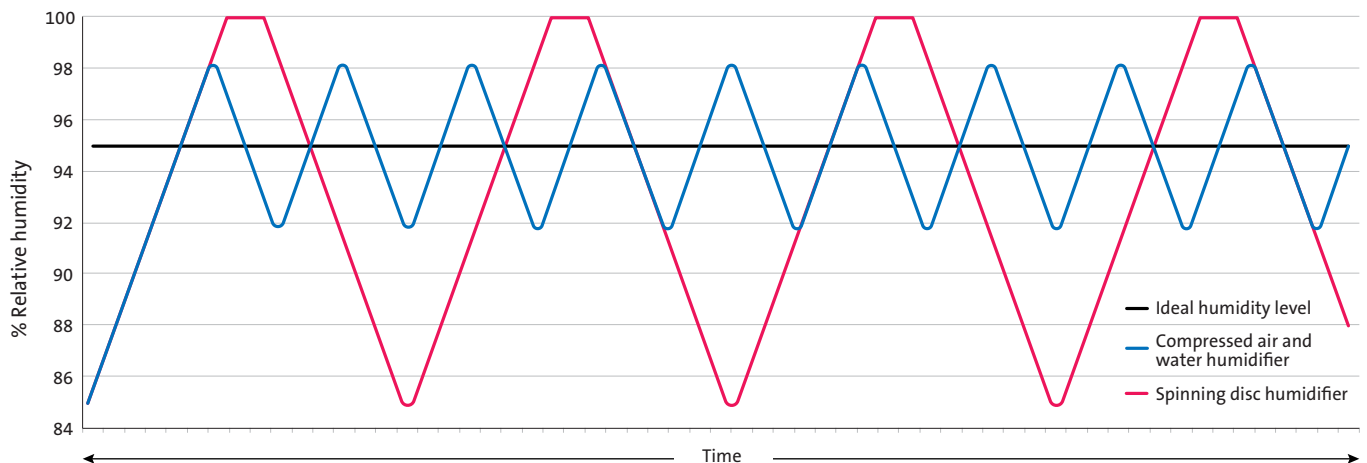
In order to minimise any fluctuations in the humidity level away from the optimum, it is essential that the humidifier and its controlling humidistats react rapidly to any change

away from the desired room condition. Humidistats should be high precision units (see point 9) and humidification needs to rapidly delivered around the room when needed (see point 3).

Typically tea fermentation areas are humidified with an individual spinning disc humidifier controlled by a cotton or plastic film based humidistat. This humidification system can at best

provide +/-10%RH control, which can mean the humidity level fluctuating between 85-100%RH.

A compressed air and water spray humidifier combined with precision hygostats can deliver a 95%RH set point with fluctuations between 92-98%RH, offering a much more consistent humidity level.





The smaller a humidifier aerosol's spray droplet size, the more rapidly it will be absorbed by the air. Sprays with small droplets result in shorter spray lengths and less risk of wetting onto objects, ceilings or walls in the room.

Humidifiers that combine compressed air with water have the smallest droplet size and also offer the benefit of guaranteed drip-free operation.

This avoids the possibility of wetting on the floor under the points of humidification or on the tea itself.

In addition to a small droplet size and fast evaporation, compressed air provides highly directional sprays and avoids the need for integrated fans, which can block-up with tea dust in a fermentation room and fail to operate successfully.

Type of humidifier	Spray droplet size (microns)
Compressed air and water	5-7
High pressure	15-20
Spinning disc	>20



6

VENTILATION

Maintaining a well ventilated fermentation area is essential for the oxidation process and is typically more than 15 air exchanges per hour. However, maintaining a consistently high humidity of 95-98%RH with such a high volume of fresh dry air continually being introduced can be a challenge.

The fermentation area's humidification system must have the capacity to rapidly deliver adequate moisture when required to avoid drying the tea and also deliver it where it's most required. Points of moisture injection by the area's air inlets need to have a greater capacity than those located

closer to air extraction points in order to rapidly humidify incoming dry air and avoid over humidifying air that is about to be exhausted.

7

HYGIENE



The hygiene of the fermentation area is paramount and much effort goes into keeping it clean. However, the humidification system must also play its part otherwise it could be introducing bacteria into the atmosphere, which is not only detrimental to the tea being processed but also to staff working in the area.

Any humidification system used must have automatic flush and drain cycles to ensure water cannot remain in the pipe work or tanks to stagnate. These

cycles need to run automatically during periods of operation and non-operation. Hygiene cycles typically only take a few seconds to be completed.

If humidifiers do not incorporate this safety feature it is possible microbes could grow either inside the humidifier's water tank, internal pipe work or even the building's pipe work leading to the humidifier. When the humidifier switches on these microbes could then be introduced to the room and potentially inhaled by employees.

Alongside flush and drain hygiene cycles, ultraviolet water sterilisation can be used to treat the incoming water supply and further limit the potential for microbial growth in the system and purify the water being introduced to the fermentation area.

At the very least, the water supply to the humidifier should always be of drinking water quality and correctly filtered to remove particulate matter.

TEMPERATURE & EVAPORATIVE COOLING



A typical temperature range of between 26-34°C occurs during the fermentation process. As tea oxidizes, its temperature increases. If the temperature exceeds 34°C, polyphenol oxidase can be affected, reducing the product's potential market value.

Cold water humidifiers offer a low energy way to cool an atmosphere, as evaporating water provides 0.68kW of cooling per kg of evaporated moisture. Therefore, a spray humidifier delivering 100kg/h to a fermentation area is not only maintaining the humidity level

but also providing 68kW per hour of evaporative air cooling.

When designing the fermentation area's temperature control system, it is important to factor in this reduction in temperature from the humidity control system.





A humidistat measures the humidity level in a room and sends a control signal to a humidification system to control its output. In this way the humidifier is controlled based upon the ambient humidity in the room and whether more or less moisture is required to maintain the desired room condition.

In a tea fermentation area containing a typical 30-40m long CFM machine, it is important that two or three such humidistats are used. The humidistats ought to be high precision units with an accuracy of at least $\pm 3\%RH$.

The operational control of the humidification system ought to be based on the average humidity measured across all the humidistats in the room. This is unlike most tea fermentation areas where a single humidistat is controlling the humidifier.

By using an average humidity reading across different points of the room, the humidification system is able to provide more even humidity control. If only one humidistat is used, there is increased potential for areas of high and low humidity to occur.

The humidistats should not be located near to the points of humidity injection so should be away from the nozzles or humidifier itself. They also should not be located too close to where the outside air enters the room, for instance the main doorway. This would result in a constant low humidity reading and the humidification system over humidifying the area.

It is better to locate a humidistat toward the areas where air is extracted from the room, as this has given the air time to correctly mix with the moisture being introduced to the atmosphere and will give a truer humidity reading.

AREAS THAT REQUIRE HUMIDITY CONTROL



Although this guide has focused on the general atmosphere of the tea fermentation room and improving the process of tea oxidation, there are other processes and areas of a tea production facility that will benefit from accurate humidity control.

For instance, many CFM machines will incorporate humidification systems, which typically use spinning disc technology. To enhance the humidity control of the air passing directly through the tea on the CFM machine, spray humidifiers can be employed to deliver more accurate and consistent humidification.

Humidification of the rolling room and CTC area will prevent moisture loss from the tea prior to it arriving in the fermentation room. This will ensure the maximum amount of moisture is available inside the leaf to act as the

catalyst for the oxidation process. A high humidity of around 90-95%RH will also prevent the leaf's ruptured outer surface from sealing itself, which can inhibit the oxidation process.

Although the tea spends a relatively short amount of time in this area, humidity control will still benefit the quality of the final product.

For a factory producing tea bags, controlling the humidity to around 60%RH in the filling area will help reduce electrostatic build-up. Static can cause issues with tea bags sticking to each other and problems with filling, as tea won't consistently flow. A dry atmosphere promotes static build-up and causes tea to stick and lump together, which can result in inaccurate volumes being introduced to each bag.



ASK FOR A FREE
EXPERT CONSULTATION



WORLD LEADING TEA HUMIDIFICATION SPECIALIST

Condair is a world leader in humidification and evaporative cooling. It has manufacturing facilities in Asia, Europe and North America, sales operations in 15 countries and distributors in over 40 more. As well as benefiting from the most advanced humidifier technology available, clients are supported by local specialist

humidification engineering teams, which can offer installation, commissioning, maintenance and spares support.

The company has been serving the global tea industry for many years and helps producers achieve rapid return on the investment in their humidification

systems through improved product quality and reduced waste.

Contact us today for a free expert assessment of your factory's environment and discover how improved humidification can enhance your productivity.

© Copyright Condair plc

No part of this document may be reproduced, published or distributed in any material form, including inclusion on social media or distribution via the internet, without prior consent of Condair plc.

Condair plc
Artex Avenue, Rustington, Littlehampton, West Sussex, BN16 3LN, UK
Tel: +44 (0)1903 850200 - uk.sales@condair.com - www.condair.co.uk

