

Use of the Lascaux Humidification Chamber HC-5

Organic and cellulosic materials generally account for 90% of the total weight of a graphic artwork. These materials are dimensionally unstable and are subject to constant microdimensional change due to climatic variations. Internal stresses can have a considerable impact, and dimensional changes in the order of 1/40th are not uncommon. This can eventually distort the work or, worse still, lead to creasing and deformations. It is therefore only a matter of time before the first serious signs of ageing appear, such as a loss of mechanical strength or tears along the edges of the paper.

The usual answer to this type of damage is to line the work, often with materials similar to those of the original. Unfortunately, this involves the use of even more unstable materials (animal glues, protein-based water glues, etc.) which become difficult to remove as they age and are particularly vulnerable to microorganism attack. The inevitable degradation of these materials makes relining necessary, with the result that many drawings have been lined more than once. Conservators today are often faced with structural damage, creasing and thinning of the paper due directly or indirectly to earlier linings.

Water is one of the most common factors in the degradation of works of graphic art; and, paradoxically, water is also without a doubt the most widespread substance used in restoration work. Humidifying a work is a delicate and indispensable part of the process of installing or removing a lining and of cleaning or flattening an artwork. As a rule, we use a vaporizer, hot or cold steam generators and GORE-TEX® for the humidifying stage. Because of their highly hygroscopic nature, paper and parchment react very quickly to this form of treatment, and the restorer must be able to control its effects perfectly so as not to accentuate certain deformations or weaknesses (the presence of a water-sensitive medium often brings further problems). Water can be as disastrous in its effects as it can be beneficial, which is why control of this element is crucial. The humidification chamber and the suction table presented here are two equipments which together meet the desired requirements.

The Lascaux Humidification Chamber HC-5

The Lascaux humidification chamber HC-5 is an equipment for relaxing the fibrous tissue of a paper work. It also allows to soften adhesives safely and in a much gentler fashion than any other method, by creating a controllable moist environment. The work is permanently visible through the window, and at the end of the treatment seems to have been remarkably unaffected by the process because it has only absorbed the amount of water that is necessary to relax it. This low level of water input enables the conservator to work on objects

which would not withstand other humidification methods. Moreover papers which have been humidified using this chamber are less prone to distortion than those humidified by other conventional methods. The long humidification process (up to 24 hours) ensures perfect penetration of the paper fibres¹ by the moisture. In this way, the paper retains a certain amount of mechanical strength, thereby avoiding the risk of tearing during handling.

Hydrophilic and hydrophobic properties of paper

Water is a very active solvent of paper for both chemical and physical reasons, because it is very hydrophilic and porous. The internal structure of paper consists of layers of cellulose forming a capillary network of variable density depending on the manufacturing method employed:

Paper is a heterogeneous material because the cellulose fibres are not all of the same size or thickness and contain crystalline and amorphous zones.²

Highly refined fibres are more hydrophilic but also more supple, yielding a more compact paper. If the fibres are refined further, the largest ones may flocculate, i.e. clump together to give the paper an irregular texture. A highly calendered paper will be more compact and therefore less porous than a non-calendered one (this is one of the basic differences between tracing paper and watercolour paper). Size, by fixing to the cellulose, makes the paper hydrophobic, thereby preventing the colours in water-based graphic media from spreading.

Water-to-paper bonding levels

When a drop of water is deposited on the surface of a dry paper, it spreads laterally and vertically through the paper by capillarity, forming a multitude of hydrogen bonds with the cellulose. According to James Cazez,² water is so bonded to cellulose that a paper which has been dried at 100° C (212° F) will still contain between 0.5 and 1% water. Water is at the origin of the inter- and intra-molecular bonds within the cellulose which give it its stability and also enable the polymer chain to form microfibrils, then fibrils and fibres, before resulting in the fibrous tissue of the paper. Depending on the quality of the fibres, a paper may contain between 15 and 30% water in a saturated atmosphere. Water is retained in the paper by various means, and is called colloidal water, capillary water or excess water, according to the bonding level:

Colloidal water (approx. 3-4% water content of the

¹ Refining consists of a system of knives in a water suspension and has the purpose of fibrillating the fibres. Fibrillation loosens the threadlike elements known as fibrils that make up the structure of the fibres by relaxing the weakest internal bonds.

² See Bibliography.

paper) is strongly connected with the cellulose molecules by hydrogen bonds and is almost never affected by conservation treatments. The physicochemical properties of colloidal water vary somewhat from those of "free" water. Colloidal water has an abnormally high density, a different freezing point, does not act like a solvent, is virtually insensitive to water treatments, and does not have the same vapour pressure.

Capillary water is held in the capillaries by hydrogen bonds. The percentage of capillary water depends on the relative humidity and corresponds to the point of equilibrium between the paper and the environment. It varies continuously because exchanges between the paper and the atmosphere are taking place all the time. When flattening paper, what interests us is the capillary water, as this gives the paper its suppleness.

Excess water appears in the paper from the "critical humidity point" onward and corresponds to the fibre saturation point. This level of humidification is achieved when a paper is impregnated with water by immersing it in a water bath or by atomizing a large amount of water onto it. This makes the paper transparent by modifying its refractive index. As it penetrates the paper, the water first hydrates the amorphous regions of the cellulose, which are more reactive, more fragile and more easily reached; the polymer chains spread out, thereby facilitating the hydration of the other regions. This hydration is expressed by a swelling of the fibres and dimensional variations in the paper sheet.

Description of the Lascaux humidification chamber HC-5

Dimensions: 158 x 108 x 55 cm. Aluminium casing, stove-enamelled.

The chamber has a glass front door, giving access to the nylon grid form, and is equipped with ceiling illumination. The artworks to be treated are placed on the nylon grid and are separated by blotters to prevent the vapour from condensing in contact with the grid and to direct it towards the work. The regular flow of cool mist is produced by an external ultrasonic humidifier connected to the chamber by a flexible hose. The cool mist circulates round the papers undergoing the treatment, slowly swells the layers of glue and gently relaxes the paper. A hygrometer provides perfect control of the ambient humidity.

A fan inside the unit increases the kinetic energy of the water molecules, reduces the condensation phenomenon, and encourages the even distribution of the vapour around the objects. To guarantee the climatic stability of the chamber, the fan motor should be set at a slow speed. Setting the fan speed too high could lower the temperature, leading to condensation on the ceiling of the chamber. To prevent this happening, the ceiling is equipped with a heating system which can be set for a minimum temperature to keep the surface of the objects from drying out. If the temperature is too high, the relative humidity is reduced and it is no longer possible to humidify a paper enough to ensure the success of the required treatment. It is also advisable to keep the light

turned off while treatment is in progress so as not to raise the temperature inside the unit.

Hydration generally involves some degree of expansion. As the component parts of a work do not all have the same hydrophilic character, attempting to rush the humidification process can have disastrous consequences. The hygrometer makes it possible to program a very slow and progressive rate of humidification based on the slowest hydration speed of the various elements involved (support, adhesives, binders, pigments, etc.). The hygrometer is therefore a safety guarantee for the conservator because it allows the user to select a certain level of humidity and maintain it indefinitely. To avoid water condensing it is advisable to increase the humidity in the chamber slowly and evenly (though the air-circulation rate can also be raised slightly).

Verification and fine adjustment

100% relative humidity can be achieved in about 12 minutes. Good moisture distribution, thanks to the air-flow, has been tested with filter paper impregnated with cobaltous chloride salts. Papers treated in this way are blue when dry and turn pink as the relative humidity rises. The tests indicate a uniform increase in humidity right across the chamber.

Humidifying a paper

The vapour generated by the ultrasound humidifier migrates into the paper, where it is adsorbed onto the walls of pores and forms a monomolecular layer before condensing in the narrow sections and filling the capillaries. Liquid water fills the largest pores first. But here the opposite happens (the vapour first condenses in the finest capillaries), and the volume of water delivered by this type of humidification is much smaller than by conventional methods. There is no excess water, because the paper finds a state of equilibrium with a relative humidity close to saturation. Relaxation takes place and the paper becomes more supple and dimensional variations are less than those induced by humidification using the conventional methods.

With more traditional humidification, the paper reaches its critical humidity point and contains excess water.

Drying a paper saturated with water in the open air can be divided into three phases:

The excess water evaporates off the surface of the paper. This stage goes quickly and can be further speeded up according to the humidity, temperature and circulation speed of the ambient air. Characteristic of this stage are the gloss and relative transparency of the paper. From the critical humidity point onwards, the rate of evaporation falls. The water evaporates from the inside of the paper and no longer from its surface. The molecules therefore have to expend more energy to escape from the liquid because the fibrous tissue closes up and the capillary pressure increases. The evaporation rate at this stage depends not only on external conditions but also on the degree of hydrophilia of the paper. It is at this stage that the paper has a tendency to cockle because it is not drying evenly and the fibres have to

reorganize themselves under a range of stresses induced by the drying.

Evaporation virtually ceases as equilibrium sets in between the paper and the relative humidity.

Humidification in the humidification chamber introduces no excess water and is much more uniform and less abrupt. The first drying stage as described above, therefore does not exist for papers humidified by this method. The paper will also show less tendency to deform during drying, especially if the process is retarded and takes place in a controlled atmosphere.

If the conservator wants the paper to absorb a large quantity of water, it is not enough to provide a high relative humidity. The saturation level of the unit must also be raised and this is temperature-related. If the room containing the humidification chamber is too cold, the maximum amount of water vapour the chamber can contain may be insufficient to ensure a good level of humidification and some of the vapour may condense if the output rate of the ultrasonic device is too high. The optimal ambient working temperature for the humidification chamber is therefore between 17 and 22°C (63-72° F).

Although the air circulation inside the humidification chamber is very regular, it may sometimes happen that the upper surface of the work is more moist, particularly if the work is on blotters. This difference in humidification can be an advantage to the conservator. The object may be placed face-up or face-down on the blotter, depending on the nature of the work and the conservation problems involved. Particularly fragile surfaces (e.g. gouaches containing colours which may bleed) can be protected by securing the edges of the work, face-down, onto a blotter. This avoids any direct contact between the paint layer and the moisture.

Removal of lining after humidification

Removing the lining from the work should be commenced once the glue is completely soft. The support lining can be separated from the original by slipping a scalpel or Teflon spatula between the support and the work, if possible face-up to avoid damaging the surface (this applies particularly to pastels, charcoal, etc.). Removal should be completed in one go, without interruption, so that the old glue does not have the time to dry. It is often possible to preserve a removed support lining, because the lining retains sufficient strength despite the high degree of humidity needed to soften old adhesives. However, it is important to make sure that the expansion capacity of the support lining is not greater than that of the original support otherwise it could tear, particularly if it is only glued along the edges of the support. In such cases, the support lining should be thinned down mechanically prior to humidification. Although, as a rule, all water-soluble adhesives can be softened in the humidification chamber, some glues can prove particularly stubborn. In such cases it may help to apply the heating system during the final hours of humidification or use in a hot-vapour (steamy type) during the removal of the lining.

Cleaning foxing

Cleaning foxmarks in pastel drawings can present a whole range of problems. The first step is to humidify the work for about 6-8 hours before treating it on the low-pressure table. Once the fibres are swollen, the drawing is placed face-up on the low-pressure suction table and aspirated gently for a few minutes. The marks now migrate from the moist work into the underlying blotters. The still-moist work must then be returned to the humidification chamber (the blotters having been changed in the meantime). This process is repeated as often as necessary. It is important never to let the work dry out completely, as this would jeopardize the cleaning process. If the treatment is interrupted too soon, the foxing risks rooting itself firmer in the paper and will be harder to remove later.

Changes in colour

The colours in traditional watermedia contain binders like gum arabic, egg albumen, gelatin, egg yolk etc., as well as plasticizers such as honey which are prone to dehydration as they age. This can make the colours duller and matter. In some cases, treatment in the humidification chamber can regenerate these binders or plasticizers, resulting in richer, more brilliant colours³. It is impossible to say how long such regenerations will last; the colours will certainly fade again sooner or later, depending on the conservation conditions of the work.

Advantages of the humidification chamber HC-5 in brief

1. Humidity can be exactly controlled.
2. The humidity acts uniformly on the paper. It does not wet the surface of the work but penetrates deeply and evenly into the paper fibres, thereby avoiding stresses and deformations.
3. Uneven stresses and deformations in the paper can be treated during humidification.
4. Treatment can be interrupted at any time if the integrity of the work is threatened (by colour migration, etc.).
5. Delicate objects (pastels and other media with low binder content) can be kept facing up during the treatment without the surface being in contact with anything. This is also a great advantage in the case of paint layers containing a high percentage of binder.
6. The work can be observed through the glass front door while treatment is in progress.
7. Lining removal (separating a work from an auxiliary support) is one of the most important operations which can be carried safely with the help of the humidification chamber HC-5.

³ See M.K. Weidner 1993; A.F. Maheux and W. McWilliams 1995.

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