IIC-ITCC: SCIENTIFIC APPROACHES TO PREVENTIVE CONSERVATION COURSE

TEMPERATURE AND RELATIVE HUMIDITY

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1. DAMAGE CAUSED BY INCORRECT RH

1.1 Damp (over 65%)

- Causes mould (which stain and weaken organic and inorganic materials).
- Corrosion (of metals).
- Shrinkage (of tightly woven textiles).

1.2 Dry (under 50%)

- Causes shrinkage of moisture-containing materials resulting in cracking and breakage (of wood).
- Desiccation (of glues).
- Veneers detach.

1.3 Fluctuations

- Shrink and swell unconstrained organic materials.
- Crush or fracture constrained organic materials.
- Cause layered organic materials, which expand and contract with changing RH, but at different rates, to delaminate, tent, and/or buckle.
- Loosen joints (in furniture).

2. TEMPERATURE

- People very conscious of temperature.
- Comfort heating 18-25C.
- Artefacts least sensitive to temperature.
- Rate of chemical and biological changes increases as temperature increases.
- Lower temperatures will slow down chemical and biological change.
- RH increases as T decreases.
- RH decreases as T increases.
- When people comfort does not need to be considered (ie NT houses in winter and storage), heat to give required RH (conservation heating).
- Avoid direct heating (overmantels, above radiators) since it can cause local drying.
- Avoid sunlight, powerful spotlights and lights in confined spaces.
- Avoid condensation by keeping objects above dew point temperature of air.

3. DEFINITION OF RH

- Moisture content of object is mainly determined by relative humidity of air surrounding it, T has minor effect.
- Aim of environmental control is to keep moisture content of objects as constant as possible to prevent dimensional change.
- Warm air can hold more than cool.
- Need scale of relative humidity.

$$RH = \frac{\text{amount of water in a given quantity of air}}{\text{maximum amount of water the air can hold at that temp}} \times 100\%$$

- High value of RH in the air surrounding an object will cause it to absorb water.
- Low value of RH will make it dry out.
- Recommended levels of RH are influenced by climate and the type of object in the collection.

65% Mixed collection in humid tropics. (Air circulation is important to discourage mould growth.) Too high for metals.

55% Mixed collections in Europe and North America. (May cause frosting and condensation problems in museums where winter temperatures are low.)

45-50% Compromise for mixed collections in museums where winter temperature are low. Best for paper and textile collections.

40-45% Metal-only collections. Local material exhibited in museums in arid regions.

- Level to which objects have become acclimatised is most important.
- Before changing anything it is important to monitor the condition of the object, and the environmental conditions for at least one year.

4. SPECIFICATION FOR RH CONTROL

- RH specifications have become very stringent
- 20C/50% RH is typical
- Based on performance of control equipment rather than object need
- Very expensive to achieve, capital and running costs

International Bizot group specification for international loans:

- 40-60% rH
- 16-25 degC

Are such tight specifications actually necessary?

5. PSYCHROMETRIC CHART

- Psychrometric chart relates air moisture content, T and RH.

6. RH MEASUREMENT

- Instruments that measure RH are called hygrometers.
- Five types of interest to museums.

6.1 Psychrometers

- Psychrometers (wet and dry-bulb hygrometers) are intrinsically accurate when properly used and may be used to calibrate other types.
- Whirling hygrometer works by the cooling effect of evaporating water.
- The drier the air, the more water will evaporate and the greater the cooling effect will be.
- Two identical thermometers are mounted side by side.
- Bulb of one is surrounded with a wick saturated in distilled water.
- Evaporation from the wet bulb is accelerated by passing a current of air over it, by whirling the instrument or with a mechanical or electric fan.
- The drier the air the lower the wet bulb temp will be relative to the dry.
- Relative humidity calculated by comparing temperatures of dry and wet bulbs.

6.2 Hair or paper hygrometers

- Have an element that expands or contracts with changing RH.
- Must be recalibrated at least once a month.
- Recording thermohygrographs contain hair hygrometers.

6.3 Electronic hygrometers

- Electronic hygrometers rely on a change of electrical property with RH.
- Novasina MIK 3000C/Vaisala HM34 change capacitance with changing RH.
- Recalibrated with a cap containing a saturated salt solution.
- Sensors can be connected to data loggers or Building Management Systems (BMS) wired into a building.
- Electronic dataloggers, which can be mains or battery powered.
- Squirrel (from Grant Instruments Ltd) dataloggers used for past fifteen years
- Humbug dataloggers (from Hanwell Instruments Ltd) have been introduced recently. Stand-alone single-point T/RH measurement.
- Telemetric systems now available that send signals by radio.
- Major advantage is no wiring needed.
- Installation costs reduced.
- More importantly **NO** damage caused to historic buildings.
- Systems available from Hanwell, Eltek (converted Squirrel) and Meaco.
- T/RH and light/UV sensors available from Hanwell/Meaco.

6.4 Dewpoint meter

- Dewpoint meters contain a mirror that is cooled until condensation occurs.
- This temperature is the dewpoint of the air.
- By comparing it with the T of the room, the RH of the air can be established.
- They are expensive and more suitable for use as laboratory instruments.
- They are intrinsically accurate.
- NT dew point meter used for calibrations traceable to national standards required.

6.5 Impregnated paper RH indicators

- Impregnated paper RH indicators change colour as RH changes.
- Cheap and useful if a lot of hygrometers are needed.
- Eg inside cases.

7. RH CONTROL

RH control is easier in historic houses than in museums because:

- many historic houses are closed in the winter.
- temperature can be controlled for good of contents, not people.

It is more difficult because:

- Architectural importance of buildings.
- Ductwork and space for plant difficult.
- Adding moisture may cause condensation.
- Taking away moisture may draw salts through structure.

8. NO ENVIRONMENTAL CONTROL

- Monitor T/RH for one year
- Survey state of building
- Monitor condition of artefacts over time
- Establish priorities using preventive conservation framework
- Security/fire detection/building maintenance may be more important than RH control
- Do not be afraid to do nothing if other priorities exist
- In UK natural conditions in buildings with no heating or environmental control gives rise to damp conditions.
- Average RH 75-90% throughout the year.
- In UK occasional summer conditions give rise to excessive solar gain.
- External shading is more helpful than internal.
- Some houses have external blinds (eg Waddesdon).
- Rings over the windows on the south-facing side of Kingston Lacy, may have been for blinds.
- In tropical climates T/RH high for much of year
- Mould would be expected but often does not occur
- Importance of ventilation and air circulation
- Do not interfere with a building that works

- Air conditioning may be a disastrous addition

9. AIR CONDITIONING

- Air conditioning needed for full T/RH control and pollution removal.
- Very expensive and destructive of building fabric.
- Plant and ductwork occupy much space.
- Humidification may cause problems (see below).

10. CONSERVATION HEATING

- T less important to control than RH
- Lower T preferred to reduce rate of chemical and biological change
- T changes may affect some materials with high T coefficients of expansion
- Keep dimensional stability by keeping moisture content constant
- Dimensional change may cause damage to constrained objects
- Change in moisture content of wood caused by 4% change in RH same as 10C.

10.1 Heating to reduce RH

- Conservation heating is the main form of RH control used in NT houses.
- Constant T does not give rise to constant RH.
- Air moisture content varies as external temperature changes.
- In the UK raising the temperature by 5C will reduce the average RH to approximately 60%RH.
- Low winter T not high enough for comfort.
- Comfort heat offices, flats and room in house for staff to retreat to when they get too cold!
- Use heating mats or local heaters for short time.

10.1.1 Electric heaters with humidistats

- Electric heaters, such as convectors or oil-filled radiators, can be directly controlled with humidistats.
- Trials to test power of heater required and electrical consumption.
- Cheap hair humidistats require frequent recalibration and have quite large switching differentials, resulting in a saw tooth shape on the RH trace.
- NT has manufactured an electronic humidistat which gives good temperature independence and has inbuilt upper/lower T limits.

10.1.2 Conservation heating with wet systems

- Make relatively minor modifications to plumbing to improve RH in building.
- Or elaborate controls opening and closing motorised valves on each radiator.

- Have developed humidistatic radiator valve

10.1.3 Building Management Systems (BMS)

- BMS to control heating systems on scale of whole building.
- Computer, outstations, T/RH sensors, valves, thyristors etc.
- Live T/RH readings, alarms, power consumption, data storage.
- High quality RH sensors should be used which are recalibrated twice a year.
- Can use BMS to control electrical heaters or wet heating system.

10.2 Cooling to reduce RH

- Hot humid conditions may be improved with room air conditioning.
- Air passes over colling coils, water condenses, air passes back into room.
- Condensing coils are outside window.
- Could be operated on RH priority.
- Room must be well-sealed.

11. COMFORT HEATING

- Museums open to the public during the winter will need to heat to human comfort temperatures of 18C
- In museums or historic houses that are usually closed during the winter, Comfort heating may be required for events in winter and in the shoulder months (April and October).
- Increase temperature to no more than 18C for as short a time as possible.
- This will give objects less time to react to RH change.

12. HUMIDIFICATION

- Heating to domestically comfortable temperatures of 18C without adding moisture to the air causes low RH.
- Winter dryness is often the major problem for environmental control in museums that are open during the winter.
- Major problem in occupied historic houses.
- Potential problem if we have events in houses during the winter.
- Do not use humidification to counteract winter dryness in NT houses.

Disadvantages:

- Increase in vapour pressure.
- Moisture travels through building fabric as convective routes are blocked.
- Condensation or freezing may occur in fabric.
- Fungal growth or corrosion risk.
- Condensation in unheated areas.

12.1 Atomising/centrifugal humidifiers

- swiftly revolving spindle draws fine sheet of water from reservoir to strike fixed blades and droplets which are formed are fanned upwards and evaporate a metre or so from unit
- dispense salts into the air in hard water areas
- distilled or de-ionised water only should be used
- if they malfunction, they continue to emit water into the air, unless they have an automatic cut-off

12.2 Ultrasonic humidifiers

- metal plate vibrates at high frequency to break up water droplets into fine mist
- dispenses salts into air in hard water areas
- distilled or de-ionised water only should be used
- if they malfunction, they continue to emit water into the air, unless they have an automatic cut-off

12.3 Steam humidifiers

- direct injection of steam into air
- recommended on health grounds because they present least risk of infection
- direction of steam emission away from artefacts is important
- preferable to mix steam and air in ducted arrangement before introduction into space

12.4 Evaporative humidifiers

- unheated, evaporative type with forced ventilation most common in museums
- if using tap water, frequent cleaning is needed
- moisture is mixed with air inside the unit before it is supplied to the space requiring conditioning
- on larger units fan temperature control and air filters are included; air filters should be clean, otherwise air flow, and humidification is reduced
- integral humidistats are unreliable

13 DEHUMIDIFICATION

- Dehumidification uses approximately one third the energy of heating for the same level of RH control.
- Dehumidifier reduces air moisture content/vapour pressure
- Space must be well-sealed.

Disadvantages:

- Salts may be drawn through fabric.
- Control lost when house opened increasing RH change.

13.1 Desiccant dehumidifiers

- room air passes over desiccant which absorbs water
- desiccant is regenerated by heating
- silica gel most suitable desiccant for museum use
- lithium chloride, if carried into room air, is deliquescent and corrosive to metals
- water removed as warm, moist air or condensed and drained away
- effective at all temperatures
- more expensive to buy and run than refrigerant type

13.2 Refrigerant dehumidifiers

- room air passes over evaporating coils where it is cooled below its dew point and deposits water
- air is reheated by passing over condensing coils
- water must be removed periodically and allowed to drain away
- less effective at low temperatures (Garry Thomson says swap from desiccant to refrigerant at 10C)

13.3 Storage

- Storage spaces can easily be well-sealed.
- Dehumidification is standard, low-energy method of environmental control in storage.
- Important to check that the air circulates so that there are no stagnant damp areas; it may be necessary to use fans.

13.4 Show-rooms

- Most rooms can be sufficiently well sealed as long as no building defects.
- Windows and doors need draught-proofing, chimneys blocking.
- When rooms are not sealed, for example when the house is open to the public, the dehumidifier control is lost.

14. EXHIBITION CASES

- Sometimes it is impossible to control the RH in a room.
- Or objects require a different environment from the other exhibits in a room.
- Use exhibition cases to provide a micro climate.
- RH fluctuations in an exhibition case are much smaller than in a room, provided that it is reasonably well-sealed.
- The case contains moisture-containing materials that buffer or resist changes in RH caused by leakage or temperature changes.