IIC International Training Centre for Conservation

Inaugural Programme

20-25 Sep 2015 The Palace Museum, Beijing

Scientific Approaches to Preventive Conservation

Temperature and Relative Humidity

agents of deterioration

22 September 2015

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THE PALACE MUSEUM

Relative humidity and water in materials

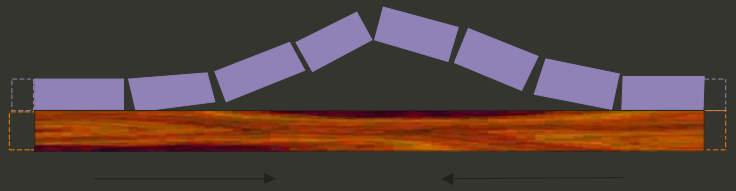
Damage caused by the wrong temperature and relative humidity

Dimensional changes
Wood and drying / low RH

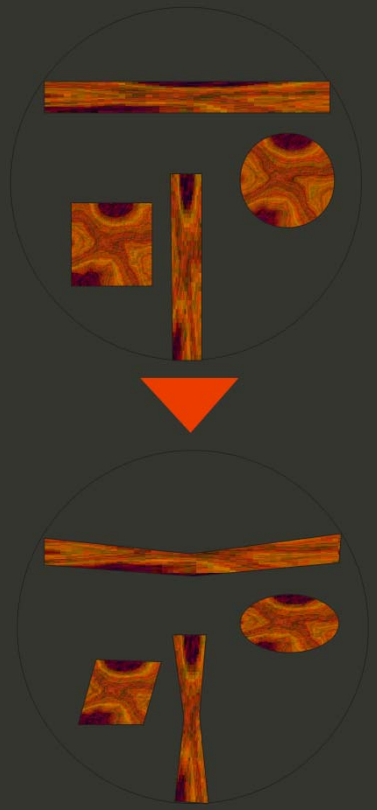
In wood: shrinkage, cracks
Other layers: disruption, flaking

RH high

RH



RH low



Water or humidity

Biological effects of high RH:
Mould and fungi

Damage caused by incorrect RH

- Damp (over 65%)
  - Causes mould growth (which stains and weakens organic and inorganic materials)
  - Corrosion (of metals)
  - Shrinkage (of tightly woven textiles)

Damage, incorrect RH: damp

Photographs courtesy National Trust, UK

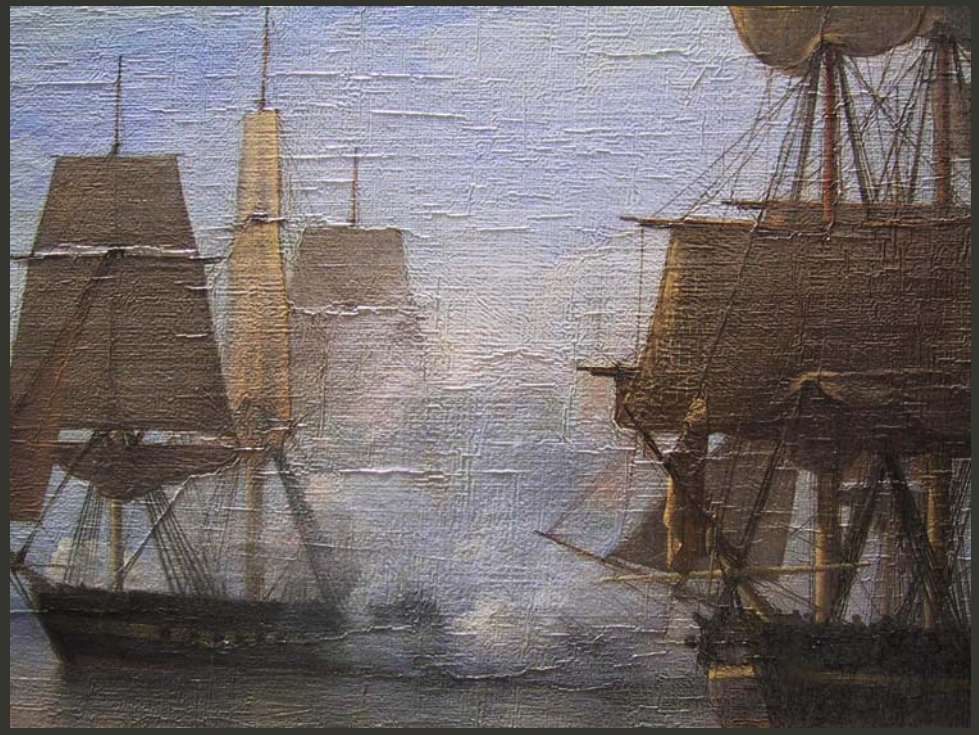
Damage, incorrect RH: damp

Photographs courtesy National Trust, UK

Damage caused by incorrect RH

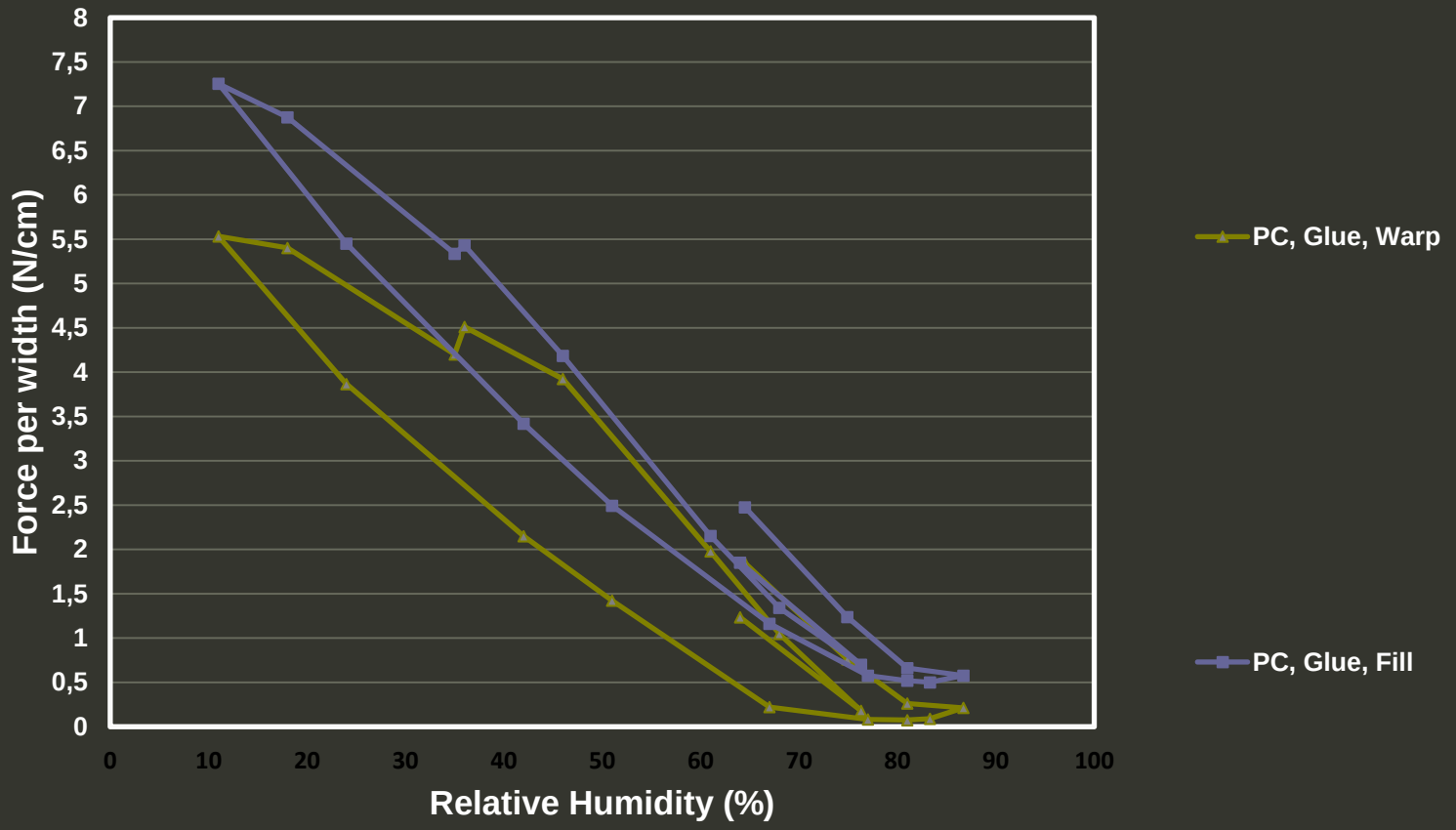
- Dry (under 50%)
  - Causes shrinkage of moisture-containing materials resulting in cracking and breakage (eg, of wood)
  - Desiccation (eg of glues) ***
  - Veneers detach

RH dry: Shrinkage restrained painted canvas (”tenting”)



Frederik Theodor Kloss, 1889,
Glue-paste lined on stretcher,
Photograph M.Scharff

RH dry: Restrained glue-paste lining on primed canvas



Response of glue-paste lining materials to changes in RH between low and high RH

C.K.Andersen: results from Ph.D. project ”Lining of canvases”, 2013

Damage, incorrect RH: dry

Photograph courtesy National Trust, UK

Damage, incorrect RH: dry

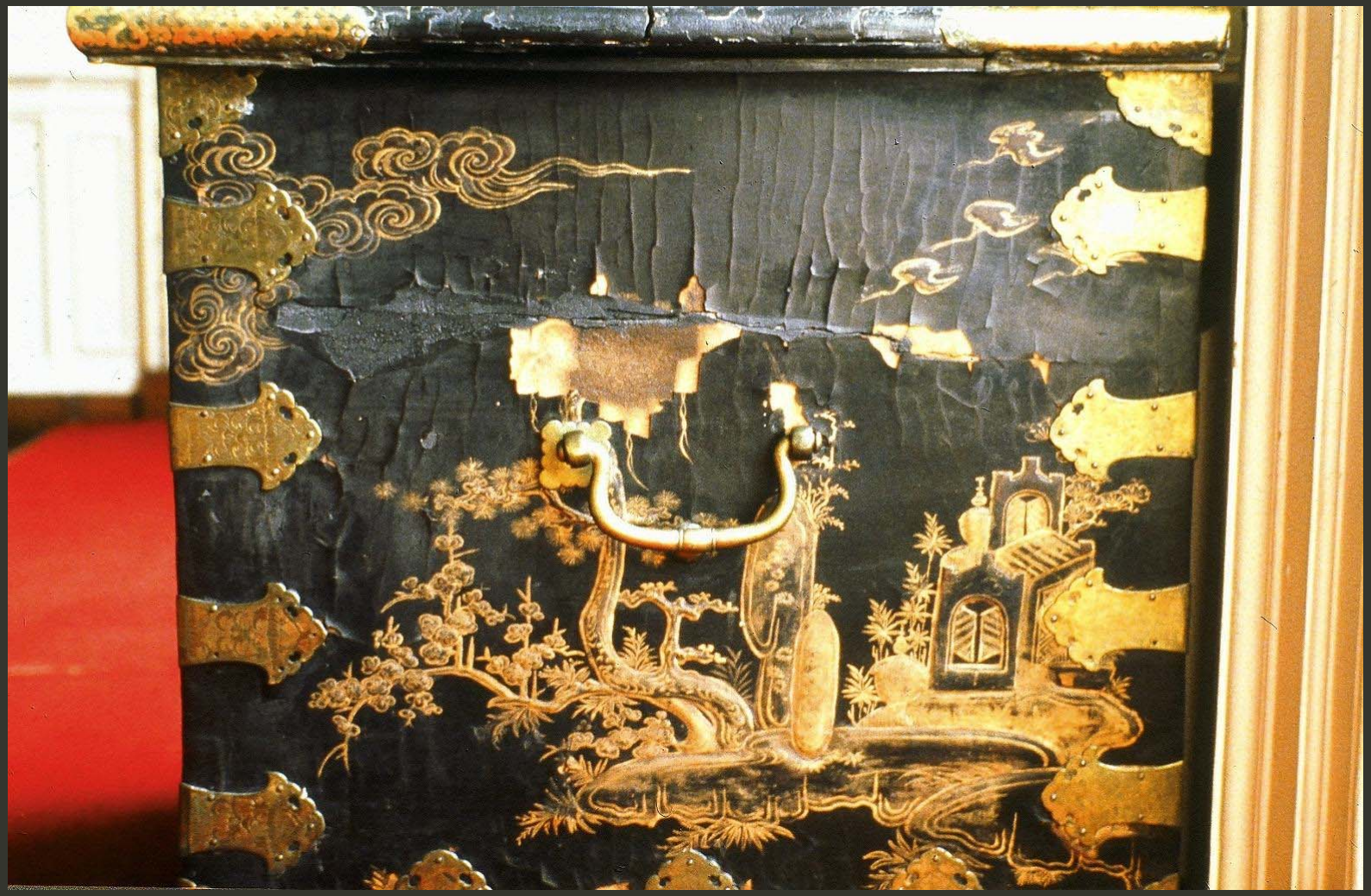
Photograph courtesy National Trust, UK

Damage caused by incorrect RH

Fluctuations

- Shrink and swell unconstrained organic materials
- Crush or fracture constrained organic materials
- Cause layered organic materials, which expand and contract with changing RH, to delaminate, tent*** or flake
- Loosen joints (in furniture)

Damage, incorrect RH fluctuations



Photograph courtesy National Trust, UK

Damage, incorrect RH fluctuations

Fluctuations NaCl around 76% RH

RH > 76%

RH < 76%

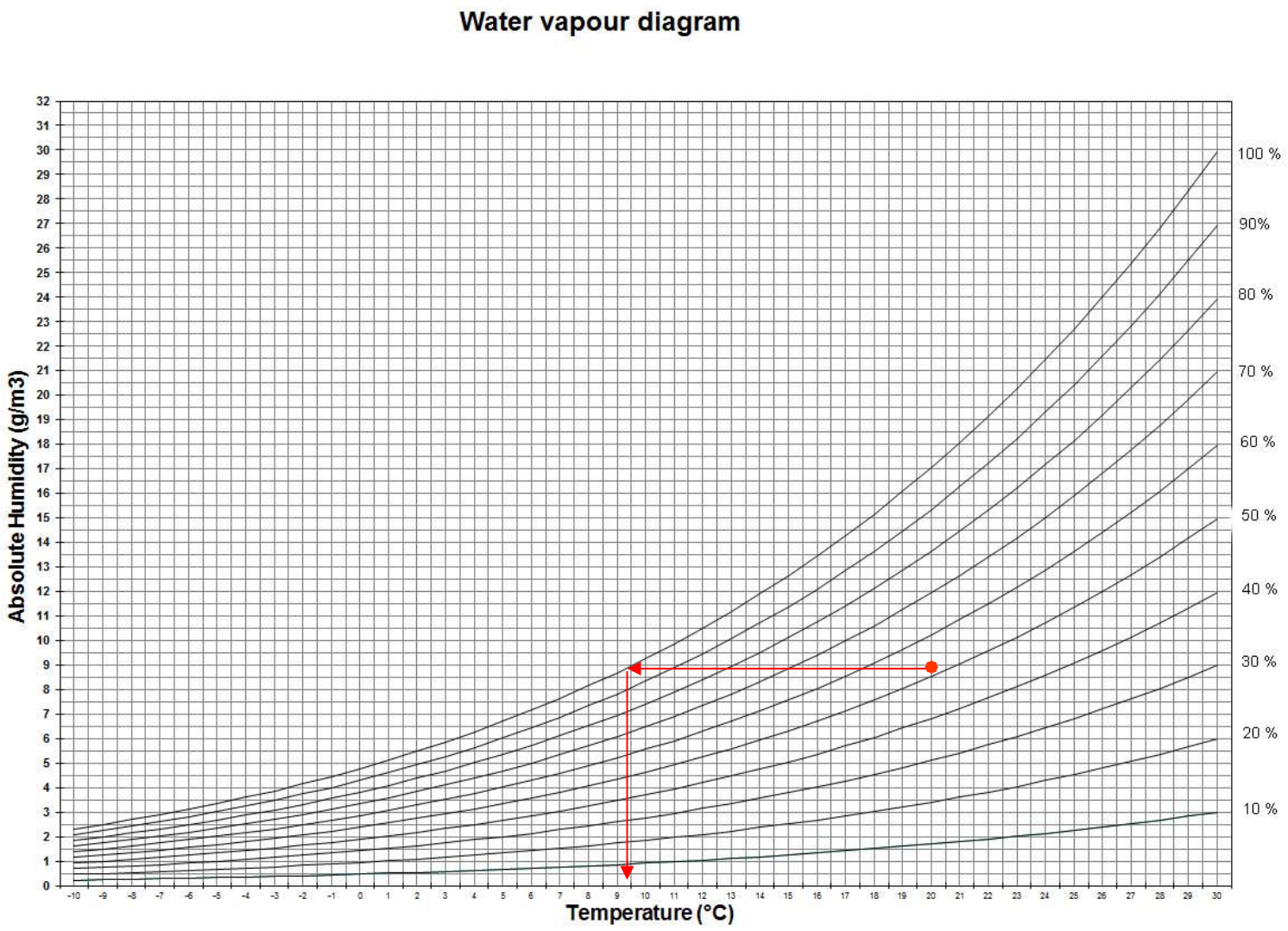
Definition of RH and AH

- Relative humidity
  - The amount of water vapour that air holds at any given temperature compared with it's maximum water content
- Absolute humidity
  - The amount of water contained in materials

50% RH

- 1 m³ of air holds about 18.0 g of water vapour at 20°C when it holds its maximum = 100% RH
- 1 m³ of air holds 9.0 g of water vapour at 20°C when it holds 50% of it's maximum = 50% RH
- Organic materials contain water in equilibrium with the relative humidity in surrounding air

Psychrometric chart



Relative humidity (RH), absolute humidity (AH)

- Typically, cellulosic materials contain about 8-10%* by weight of water (EMC, Equilibrium Moisture Content) when in equilibrium with RH 50% at 20°C
- Thus, a wood panel of 1 kg will contain about 100 g of water at 50% RH

- * Michalski, CCI web 2013, suggests 8%

Relative humidity (RH), absolute humidity (AH)

- Large changes in relative humidity cause organic materials like wood to absorb or release water
- Large amounts of water being absorbed or released may cause dimensional changes
- Small exchanges of water between wood and the surrounding air does not cause dimensional changes
- Duration of change

Relative humidity – damage caused by incorrect RH

- Relative Humidity (RH) in the sorrounding air determine the water content of many materials
- Thus, incorrect Relative Humidity (RH) may cause various kinds of damage

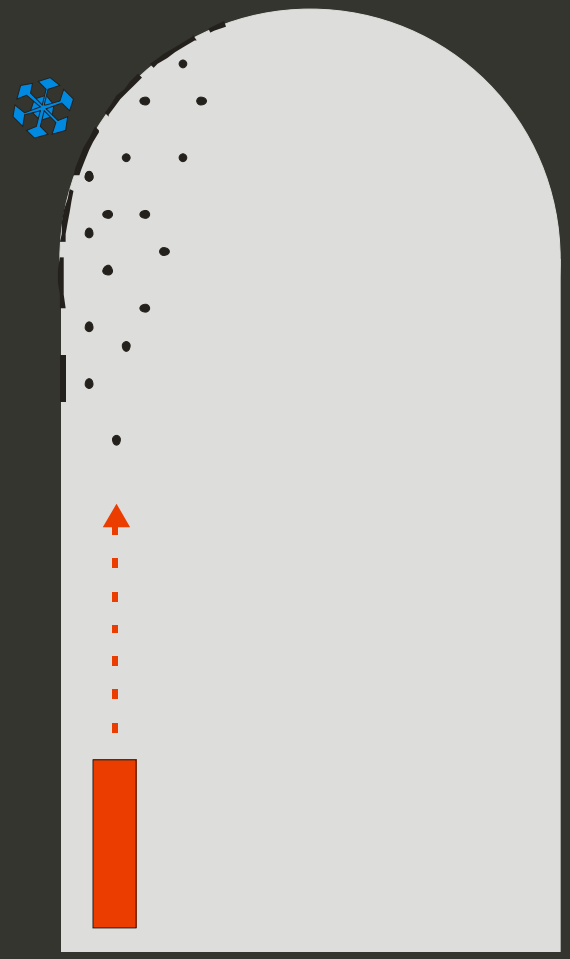
RH levels

- Recommended levels of RH are influenced by local climate and the type of objects in the collection
- Aim is to keep moisture content of objects as constant as possible to prevent dimensional change by avoiding RH fluctuations.
- If RH fluctuations are accepted: slow - seasonal

Temperature

- Speed of chemical reactions depends on T°
- Speed of diffusion
- Thermal expansion / contraction, e.g. frost
- Microbiological activity
- Movement of air
- Glass transition temperature, polymers (Tg)
- $$$ Cost of regulating temperature

Temperature, movement of air



Temperature

- People very conscious of temperature.
- Comfort heating (or cooling)18-25 °C
- - $
- When people comfort does not need to be considered (ie NT houses in winter and storage facilities), heat to give required RH (conservation heating) - (more Thursday)
- - $

Historic houses and conservation heating

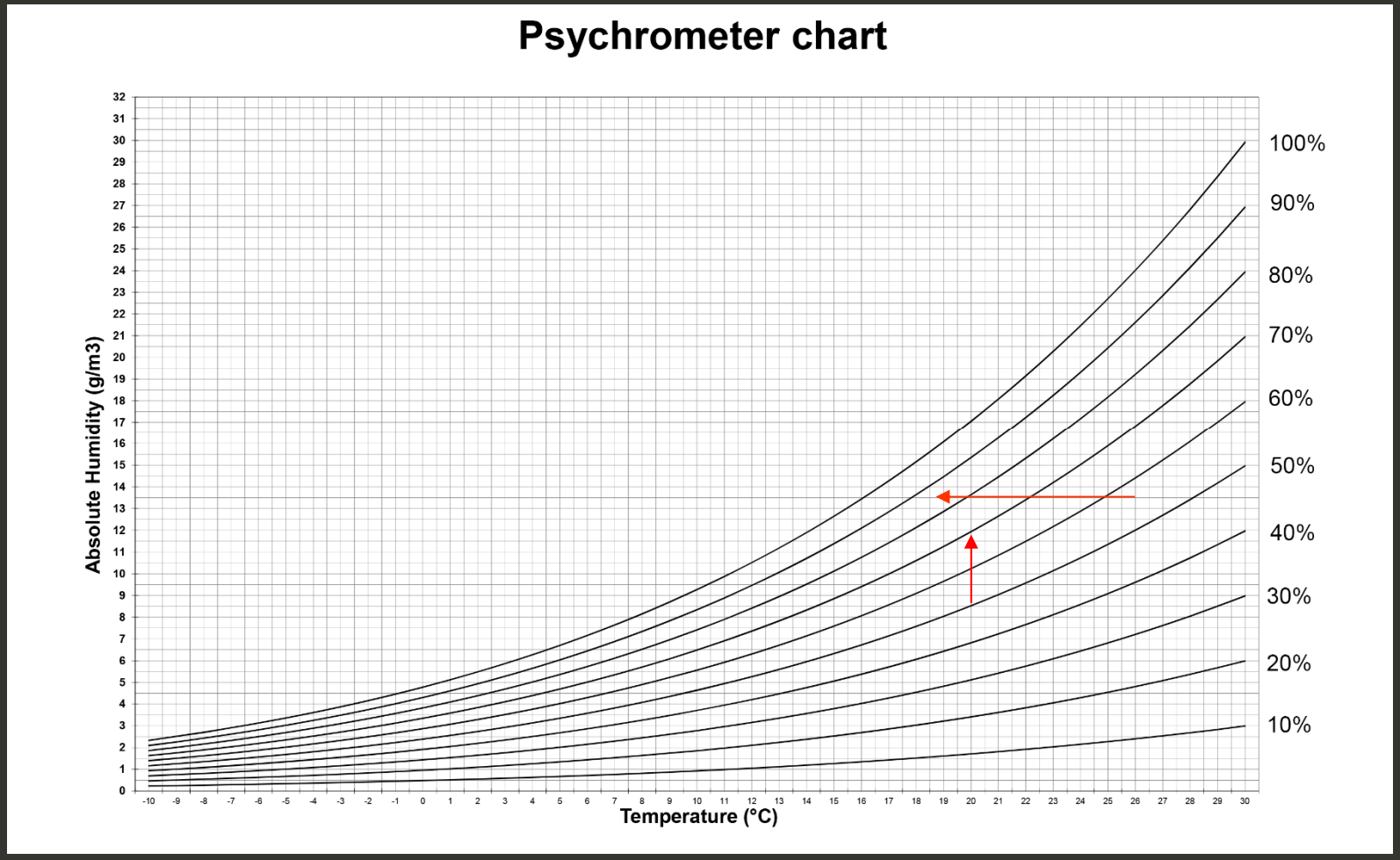
Photograph
M.Scharff

Rosenborg Castle ,circa 1610 Copenhagen, DENMARK

Temperature

- Relationship between Relative Humidity and temperature:
- RH increases as T° decreases.
- RH decreases as T° increases.

Temperature and Relative Humidity (RH)



”What if ?”

Temperature, recommendations

- Avoid direct heating (over mantels, 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

Measurement, T and RH

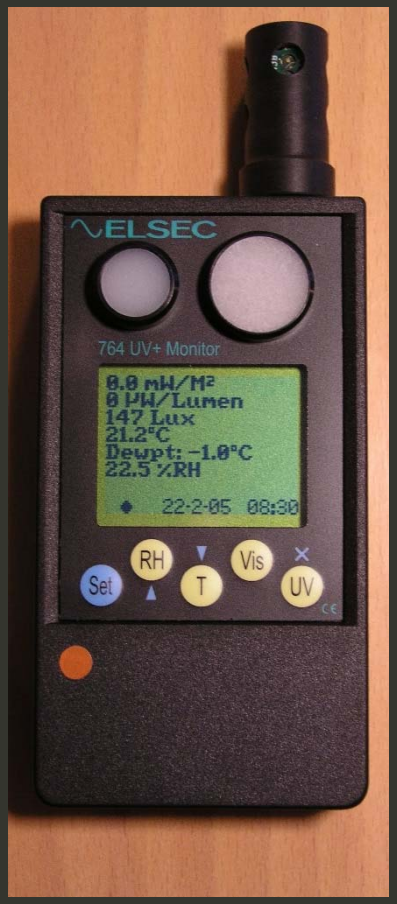
- Hygrometers measure RH.
- Five types of interest to museums.
- Psychrometers (T°-difference between wet&dry T°)
- Hair (or paper) hygrometers (organic reactions)
- Electronic hygrometers (change of electrical property with RH)
- Data loggers (cabled data transfer, radio, WiFi)
- Dewpoint meter (cooling, condensation, dew point)

Sling psycrometer, Thermohygrograph (”data logger”)

Measuring and collecting data, documentation, dissemination, research

Photographs
M.Scharff

Electronic RH measurement instruments, dataloggers



Photographs
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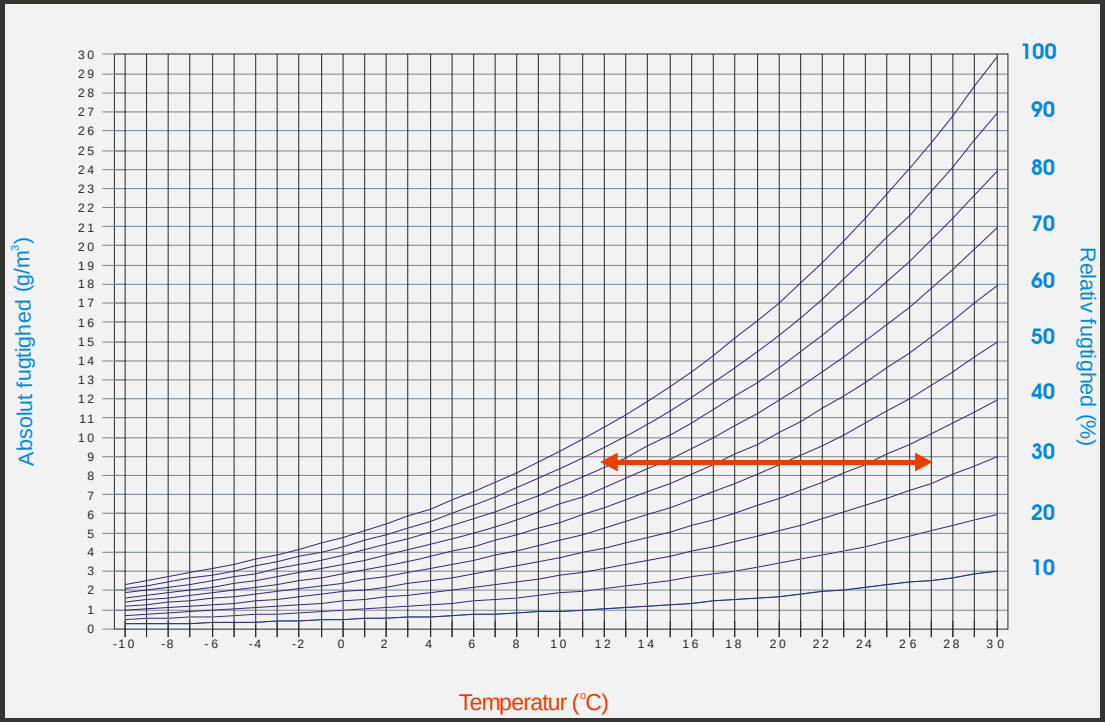
Dewpoint meter

- Laboratory reference instrument for calibration



Photograph courtesy National Trust, UK

RH norms: Garry Thomson
The Museum Environment, 1978 &1986

Class 1

Temperature:	Winter	19 +/- 1°C
	Summer	24 +/- 1°C
Relative humidity (RH)	Day and night, all year	50 or 55 +/- 5%

To be kept with the range 45 - 60% for mixed collections,

Class 2

Temperature:	As constant as possible to stabilize RH
Relative Humidity:	To be kept within the interval 40 - 70% RH

RH norms: ASHRAE
1999, 2004, 2007

Normal/ Yearly average	Control, class	short time fluctuations/gradient	Sesonal ajustments
50% RH 15 - 25ºC	AA	+/- 5% +/- 2ºC	None +5ºC -5ºC
	A	+/- 5% +/- 2ºC	+10% / -10% +5ºC / -10ºC
		+/- 10% +/- 2ºC	None +5ºC / -10ºC
	B	+/- 10% +/- 5ºC	+10% / -10% +10ºC (< 30ºC)
	C	25 – 75% < 30 (25)ºC	
	D	< 75%	
40% RH - 20ºC 30-50% RH 10ºC 0-30% RH	Cold store Cool store Dry room	+/- 10% +/- 2ºC No damp < 30%	

Recommended RH levels

- 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.

Stringent recommendations

- RH specifications have become very stringent
- 20 °C / 50% RH is typical
- Based on performance of control equipment rather than object need
- $$$ Expensive to achieve, capital and running costs, not sustainable
- IIC + ICOM-CC Guidelines

Bizot group

- International Bizot group specification for international loans:

- 40-60% RH
- 16-25 °C

- How tight specifications are actually necessary? [to be discussed …]

End

- **Acknowledgements**: thanks to Bent Eshøj (KADK) for inspiration, use of text examples and illustrations (non-credited illustrations by B.Eshøj)