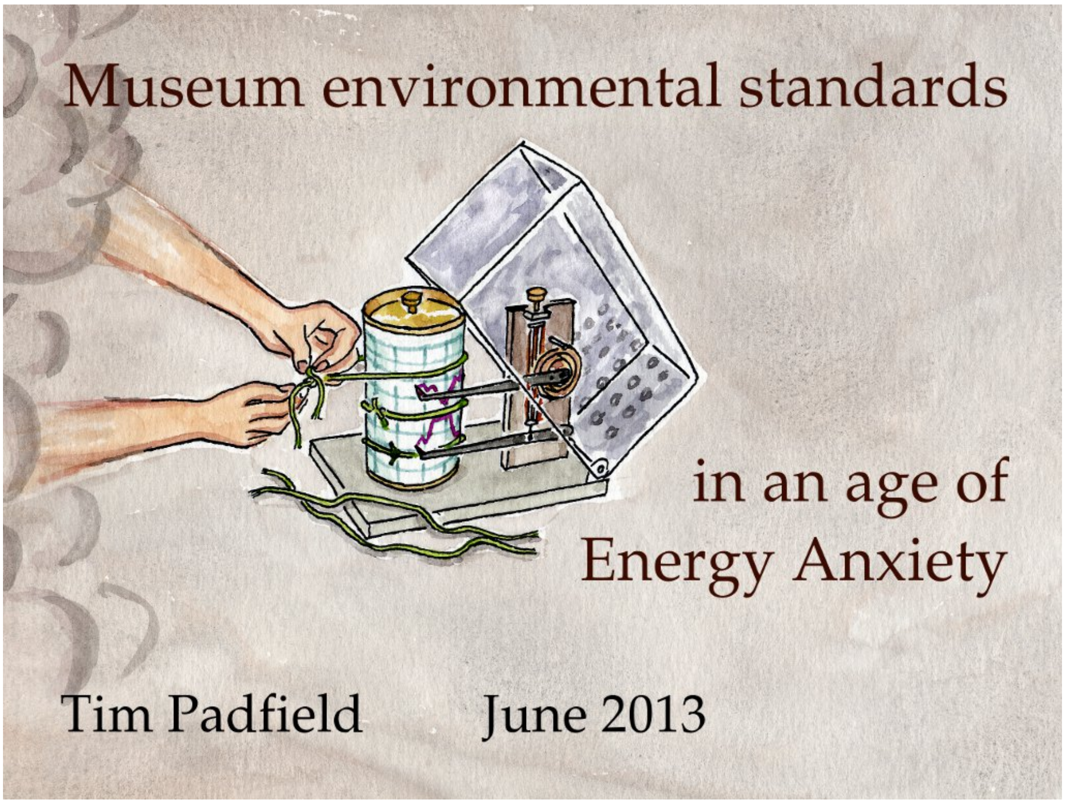

Transcript of a lecture at the National Museum of Wales conference "Sharing conservation decisions 2013".

Museum environmental standards in an age of energy anxiety

Tim Padfield

Abstract

The old orthodoxy that there is a universal specification for the ideal museum climate is fading against evidence that very different climates preserve some artifacts better and that the energy used to maintain year round constancy of climate is a serious drain on museum finances and a burden on the consciences of the museum leaders, in view of dire warnings of global catastrophe through unrestrained release of carbon dioxide into the atmosphere. A new set of environmental standards is emerging which are looser, are modest in their claims of authority, much more verbose and, as a consequence of this last characteristic, contain wrong and disputable assertions. The solution presented here is to open up the method of compiling standards by using the wiki concept of universal access to polish the text, moderated by named editors. Every five years, the text is fixed and released as a standard, while the refinement process continues on the open wiki.

Introduction

For a long time until recently the museum environment dogma was constancy of temperature and relative humidity around a fixed and universal value 20°C and 50%RH, achieved by the best available technology with scant regard for the cost.

To preserve a wall painting for thirty thousand years - it may be better to keep the RH at 99% (Fig. 1).

To preserve a paper and parchment collection for at least fifteen hundred years, 20% RH seems to be good, even with the temperature often at 30°C (Fig. 3).

This doesn't prove that the standard conditions would not do just as good a job. Figure 4 shows the altar of Gierslev Church, a typically damp northern European church. Its altar picture in oil paint on wooden planks was taken in for conservation and wrapped for slow equilibration to the 55% RH of the workshop. It never got to that RH - it developed a seriously flaking skin long before that, as the wood shrank beneath the stiff oil paint.

Conservators have long used various impregnants and varnishes to exclude a malevolent climate. Each fashionable chemical treatment in turn has in time shown its weakness.

Figure 1: The horse heads painting in Chauvet cave, France. This photo is of a facsimile; the originals are about 30,000 years old.

Figure 2: Saint Catherine's Monastery, Sinai, viewed from the north west.

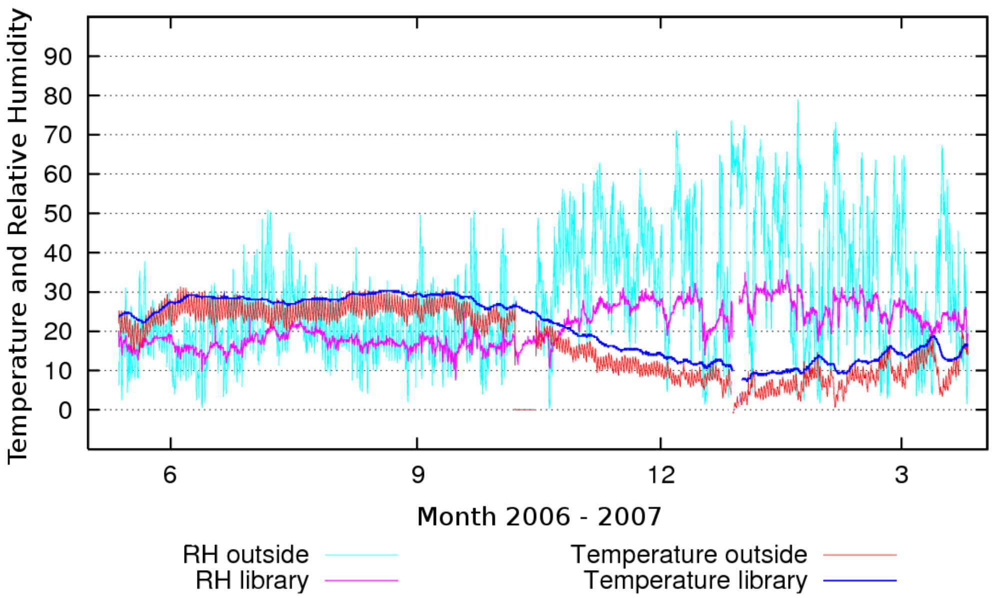

Figure 3: The climate record from a shaded gateway within the monastery and in the library. The library RH varies between 15% and 39%.

Figure 4: The altar in Gierslev Church, Denmark.

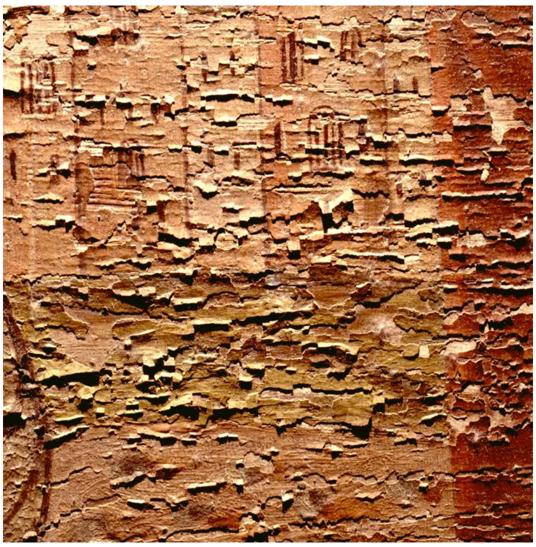

Figure 5: The paint layer, oil on wood, flaked as the RH was slowly brought down towards 55% from the approximately 90% to which the wood had been exposed for centuries.

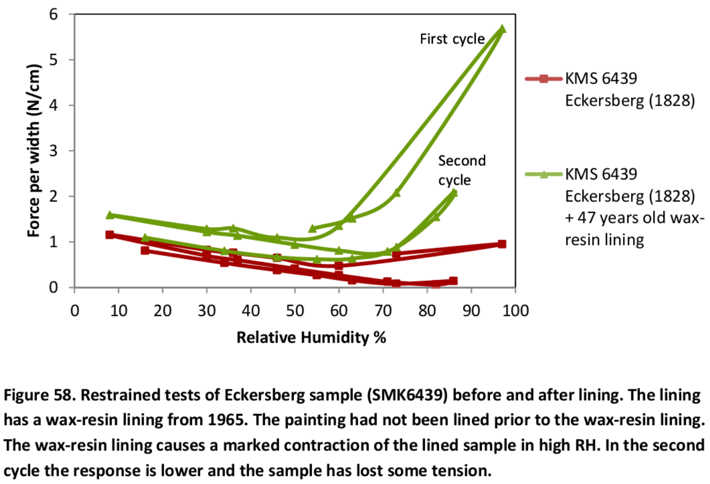

Figure 6: Stress – RH curves for bare and wax relined canvas. The wax impregnated canvas tries to shrink strongly as the RH rises above 60%. *diagram from Cecil Krarup Andersen*

Figure 6 is from the recent PhD by Cecil Krarup Andersen. It shows the influence of the RH on the stresses in the canvas of a painting by Eckersberg from the mid nineteenth century, wax relined in the 1960s. The wax has permeated the threads, which delays their humidity absorption; but the wax has also filled the voids in the weave, preventing the harmless swelling of the fibres into empty space as the RH rises. The canvas is already shrinking powerfully at 60% RH.

There are generic materials which have no definable environmental requirements because their durability depends on the permitted variation in their chemistry. The microfilm in figure 7 is decaying through separation and crystallisation of triphenylphosphate plasticiser. Microfilm plasticiser is of variable composition, and thus gives variable durability, depending on the availability and price of the alternative chemicals at the moment of manufacture.

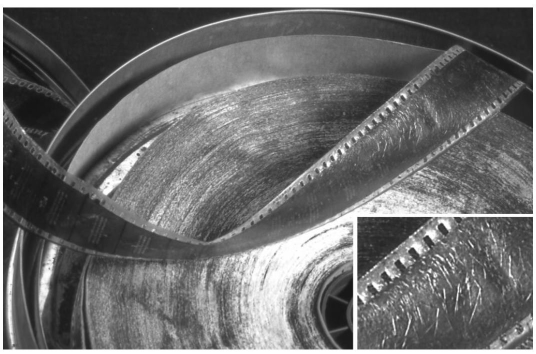

Figure 7: Microfilm showing decay through decomposition and separation of triphenylphosphate plasticiser.

Some materials, notably movie film, have long enjoyed exemption from the universal museum standard, because of research showing convincingly that their durability is short when exposed to a temperature congenial to humans. There are many more materials whose durability is doubted, but without convincing evidence what to do about it. Figure 8 shows the diversity of opinion about the best storage conditions for CDs, DVDs and other digital and analogue media.

Source	Media	Temperature	Maximum Temp. Gradient	Relative Humidity (RH)	Maximum RH Gradient
ISO TC 171/SC Jan. 2002	CD-R CD-ROM	+5°C to 20°C (41°F to 68°F)	4°C /hr (7°F /hr)	30% to 50%	10% /hr
IT9.25 and ISO 18925 February, 2002	CDs DVDs	-10°C to 23°C (14°F to 73°F)		20% to 50%	Cycling no greater than: ±10%
NARA, FAQ About Optical Media, April, 2001	CDs DVDs	68°F (20°C)	+/- 1°F /day (+/- 0.6°C /day)	40%	5% /day
National Archives of Australia, April, 1999	CDs	18°C to 20°C (64°F to 68°F)		45% to 50%	10% /24 hrs
Library Technical Report Nov.-Dec. 1997	CDs	-10°C to 50°C (16°F to 122°F)		10% to 90%	
DVD Demystified, Second Edition, Jim Taylor, 2001	DVD-R DVD-ROM	-20°C to 50°C (-4°F to 122°F)	15°C /hr (27°F /hr)	5% to 90%	10% /hr
	DVD-RAM	-10°C to 50°C (16°F to 122°F)	10°C /hr (18°F /hr)	3% to 85%	10% /hr
	DVD+RW	-10°C to 55°C (14°F to 131°F)	15°C /hr (27°F /hr)	3% to 90%	10% /hr
National Library of Canada, 1996	CDs	15°C to 20°C (59°F to 68°F)	2°C /24 hrs (9°F /24 hrs)	25% to 45%	5% /24 hrs
Media Sciences, Inc. Jerome L. Hartke	CD-R	10°C to 15°C (50°F to 59°F)		20% to 50%	

Figure 8: The variability of standards for storing CDs and similar digital archive materials.

Despite this intricate weighing of often sparse and inconclusive evidence, small local museums have continued to give reasonable protection through climate control by radiator and openable windows.

Richer institutions can also display a relaxed attitude towards exact control of the climate.

The new standards

Recent documents from the British Standards Institute and from the European Norm committees have been more tutorial in their approach - accepting that one climate specification will not be right for all collections in all geographical settings. The documents even avoid the word *standard* or *guideline*.

Support for this approach has come from the Bizot group of directors of prestigious museums: *"Museums need to find ways to reconcile the desirability of long-term preservation of collections with the need to reduce energy use."*

Figure 9: The museum of Saltholm, an island off Copenhagen. The island was used for quarrying chalk; the museum is one man's passion. It can only be reached by small boats.

Figure 10: Queen Victoria's bathing machine, exhibited in the grounds of Osborne House, Isle of Wight. The house is managed by English Heritage.

This elegantly ambiguous phrase was further softened and guarded by the text: *"A conservator's evaluation is essential in establishing the appropriate environmental conditions for works of art requested for loan."*

Figure 11: Loan exhibitions still require strict environmental standards – according to the Doerner Institute.

This delegation of decisions to the conservator is contested by the Director of the Doerner Institute, who maintains that strict standards have at least legal reasons to exist, particularly for loan contracts between museums. Furthermore, he claims that much energy can be saved without sacrificing the strictness of environmental control.

Figure 12: Thomas Young, 1773 – 1829. The English polymath of whom it was said: he was the last person who knew everything.

So now the task is firmly with the conservator, who has to add air conditioning science to her toolkit. She needs to understand the diverse weaknesses of all materials and methods of fabrication ever used by mankind, together with the efflorescence limits of inorganic salts and the biological vulnerability of dried plants. And her job is mostly hand crafted repair of artifacts.

Figure 13: The conservator's first source of advice to contribute to the exhibition committee is the corpus of museum standards, evolved by committees of anonymous delegates from prestigious organisations.

One should expect that the new crop of environmental standards, from the British Standards Institution and from the European Norm committees (CEN), should help to guide the conservator's decision, particularly as they have become quite verbose and full of advice, even on techniques of calibrating relative humidity sensors.

However, the greater ambition of the standards to expound subtle aspects of environmental control and to allow variation in its specification has allowed inaccuracy and misunderstanding of atmospheric physics to creep in. To put it more cynically, the exploded myths of earlier standards have been replaced by new myths. I pick out some of these, not in a mean spirit but to support the argument that we need a more open way of developing standards so that these errors can be caught before these remarkably expensive documents are released.

PD5454 *Guide for the storage and exhibition of archival material* encourages massive building, to give thermal capacity and therefore a more even temperature than otherwise would be the case. Let's examine this assertion.

The Cologne city archive was built in 1970 on the principle of nearly passive climate control, relying on a massive construction and occasional ventilation through small windows. It became a famous monument to low energy conservation before this became fashionable and it gave good protection until it fell into the pit of the underground railway construction. Then its protective qualities went into reverse because the mass of brick crushed the documents and dragged out the recovery process over more than a year.

Figure 14: The archive of the city of Cologne. It was built in 1970 on the principle of providing large thermal inertia to prevent the daily cycle of outside temperature from reaching the interior.

Figure 15: The archive of the city of Cologne after it collapsed into the underground railway excavation in 2009. *Photo: Der Spiegel*

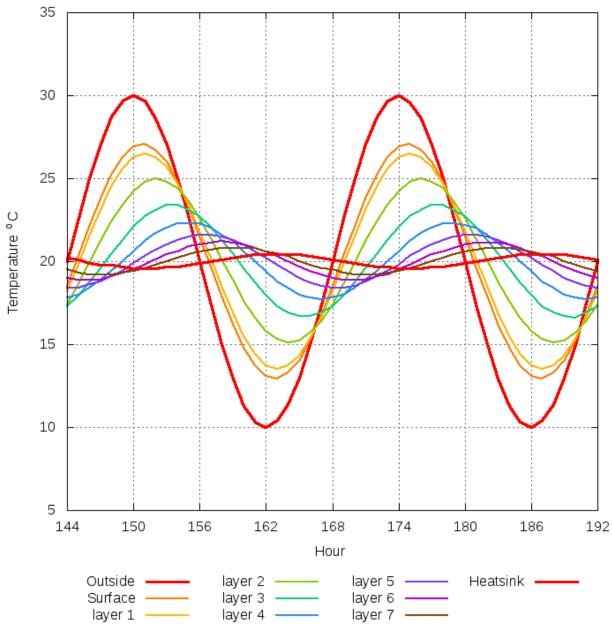

Figure 16: The daily temperature cycle through a brick wall, 240 mm thick. The most curved trace is the outside temperature, the flattest is the inside wall temperature.

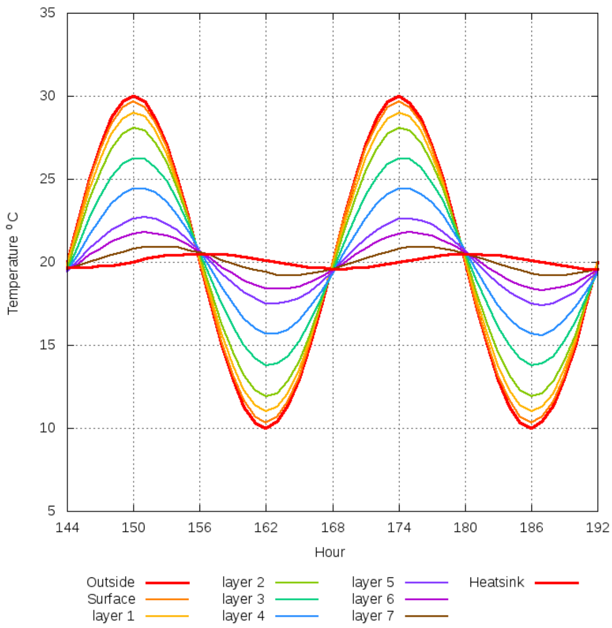

Figure 17: The daily temperature cycle through a lightweight insulated wall, 100 mm thick. The internal temperature cycle amplitude is identical to figure 16 but the time delay is less.

Thermal buffering by massive construction is easily modelled by computer these days. Figure 16 shows what happens when the daily variation in outside temperature acts on a brick wall. The wave of heat passes through the wall, but is partly absorbed within the wall, resulting in an interior surface temperature with just a feeble cycle peaking twelve hours delayed from that outside.

That is good for the archive stability, but let us compare a lightweight insulated wall (Fig.17). The pattern of heat flow is different, but the oscillation of the interior surface temperature is the same, with a smaller time offset. It would not take a year to release mildly crushed archives from a collapsed lightweight building. Indeed it might not have collapsed, in the actual situation of the Cologne archive.

It is, however, possible to buffer the temperature over a whole year by combining a lightweight building by thermal buffering from the ground below it.

Figure 18: The museum store in Ribe, Denmark.

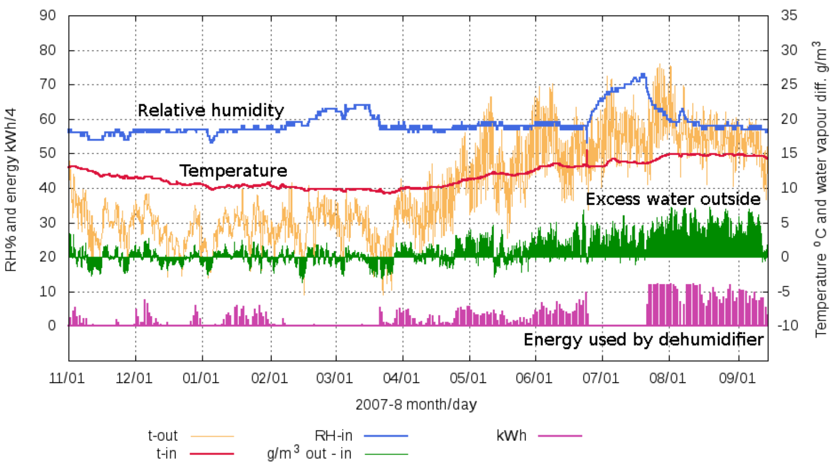

Figure 19: The climate in the Ribe store throughout the year. The temperature varies smoothly between 9 and 15 degrees.

The museum store at Ribe in southern Denmark (Fig.18) has a freely wandering temperature, moderated by heat exchange through insulated walls and through the uninsulated floor. It follows the annual temperature cycle with greatly reduced amplitude (Fig.19). Dehumidification controls the RH to a set point but the building is so airtight that very little energy is used for dehumidification. Notice the spring minimum temperature around 9°C and the late summer peak around 16°C.

Temperature buffering by the ground beneath a building is not useful for a building kept at a congenial temperature for people, which is why the building regulations of many European countries demand underfloor insulation, but in a storage building which can be allowed to get cool in winter, an uninsulated floor is preferable.

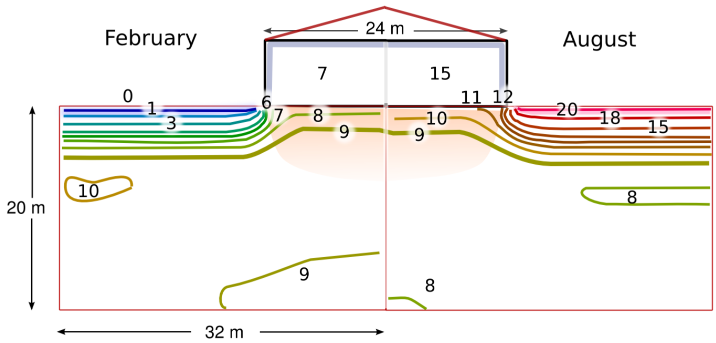

Figure 20: Computer simulation of the temperature within the Ribe store and below it. The winter situation is on the left, summer on the right.

A computer model of the ground temperature (Fig. 20) accords quite well with measured values, allowing for some heat from adjacent offices, lighting and air circulation fan. It shows the natural cycle in a single storey building in northern Europe. Note the 7°C minimum.

Let us return now to PD5454. It recommends for general archives a minimum temperature at 13°C. This forces artificial heating of such a building. Why? A study of the sparse bibliography suggests that it is based on a central European study of the separation of stearic acid from beeswax seals on documents. It is a persuasive study, but surely most documents sealed with beeswax have been exposed to less than 13°C during their existence in pre-energy boom Europe, which started in the mid twentieth century. Because of this one article, all European archives are forced to install heating, and thus reduce the chemical durability of the collection, according to the Arrhenius principle – uncontested since its proposal in the late nineteenth century. The supposedly 'aligned' PAS 198 has no such limitation and does not refer to this article. Other reasons given for this minimum temperature are procedural – the danger of condensation on bringing objects into a warm study room.

Let us turn now to the PD5454 advice on cold storage. Astonishingly, there is no defined RH. The natural RH in a cold store is always high, because the air which inevitably leaks in will have a dew point above the store temperature, so ice will condense within the cold store. However, there is also heat loss, so some part of the system must be cooler than the bulk of the space, to compensate. The RH is defined by the saturation water vapour pressure at the coolest temperature, divided by the larger vapour pressure at the temperature of the

Figure 21: PD5454 does not advocate RH control for cold stores.

main space. Left to its own devices a typical cold store runs at about 85% RH. The better insulated it is, the higher the RH.

The intricate solution advocated by PD5454 is to seal each individual item in an airtight bag, together with a RH indicator and a humidity buffer, which it states is to prevent condensation during retrieval and re-storage.

There are several disputable points here. Checking and correcting the climate inside thousands of stored enclosures is obviously more tedious than checking the climate in the archive room. Cold storage is for items that are seldom retrieved, often master copies with room temperature clones. It is likely that the RH indicator will have a shorter durability than the enclosed object.

As for the enclosed humidity buffer, it will actually cause, rather than prevent, condensation, as shown in figure 23. RH stabilisation in a rapidly changing temperature is a tricky matter which is wrongly explained in many texts. And even measuring RH in the cold is difficult.

Measuring RH in the warm is also tricky. So let me finish by moving the rocket launcher to point at a European standard, CEN 16242:2012, which, by international agreement, is inevitably also a British Standard. This is a helper standard which explains how to measure RH and how to calibrate sensors. However, it inexplicably omits the easiest calibration method - saturated salt solutions. Instead, advocating the use of a research grade climate chamber. The manufacturers of high quality RH sensors advocate the use of saturated salt solutions, and provide salt capsules to fit their instruments. I have not got an explanation from the presumed author of this standard. Like most other standards (PAS198 is an exception) the authors are anonymous but often the dominating person on the committee can be identified by idiosyncrasies in the

Figure 22: PD5454 advocates individual sealing of documents, together with a RH indicator and humidity buffer, to be placed for long term storage within a space with dangerously high RH. This requires extraordinarily good quality control of the airtight seal, repeatedly, and for centuries

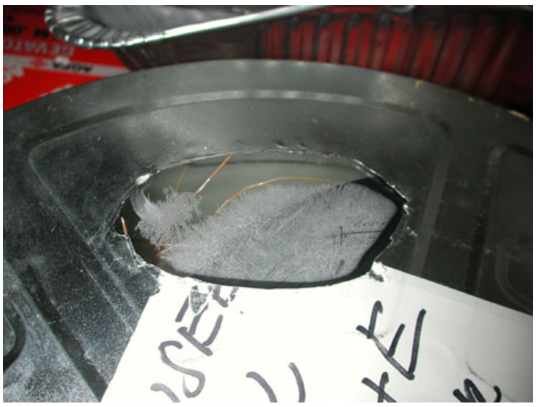

Figure 23: Film in a can with a transparent window. When the can is put into a cold store at –18°C, frost forms on the inside surface of the can because of humidity buffering by the gelatin of the film, which is transiently at a higher temperature.

Figure 24: RH remains difficult to measure accurately. The European Norm for measuring RH, now also a British Standard, omits the simplest calibration method for RH sensors.

document. In this case, the example of environment variable contours within a historic structure is a strong hint.

The solution

The current crop of standards is much more ambitious than earlier didactic instructions to enforce a single value of temperature and RH. They give advice and reasons, and often a limited bibliography. Inevitably there are direct mistakes, clumsy formulations and undue emphasis on particular materials. Sometimes, as with the standard for climate in historic buildings, one can reasonably contest the whole basis of the standard. However, the BSI system only exposes paragraphs one by one to comment, so proposing re-organisation of the topics is difficult. The window of opportunity for comment is six weeks, and not widely advertised.

The solution to this uneven quality in standards is to open up the construction process to everyone. This can be done through the wiki mechanism. Wikipedia is impressively accurate and clear in its scientific entries, so there is a good precedent for the merit of open discourse leading towards a good product.

The wiki could directly replace the current standards procedure, with a single European institution hosting the open access wiki and providing discrete editing to keep contributors on track, and polite. As now, the text could be fixed at ten year intervals and issued as a definitive document, while the

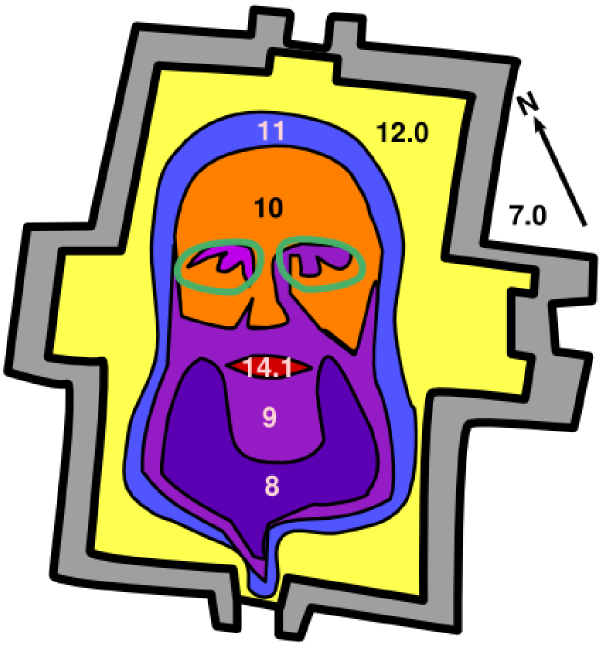

Figure 25: It is often possible to identify the principle author of anonymous standards by idiosyncracies in the document.

consultation continues to build up to the next formal issue. This model is widely used in the production of open source software, which also needs to be stringent, consistent and readable.

acknowlegements

This article draws on material gathered by colleagues at the National Museum of Denmark: Morten Ryhl-Svendsen, Poul Klenz Larsen, Lars Aasbjerg Jensen and Benny Bøhm. I also thank the anonymous authors of the standards mentioned in this article. I appreciate their voluntary contributions. However, the influence of the standards on the building and functioning of museums is so profound that failing to point out defects would be to put deference to authority before testing its right to respect.

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