More on Climate Control in Museums

The following three articles and announcement address the issue of climate control guidelines in museums. The articles by the CAL group and Steven Weintraub were solicited by the Newsletter. Barbara Applebaum's is a slightly revised version of her posting on the Conservation Distribution List on CoOL. The CAL announcement was likewise first posted on the Distribution List.

Four articles on the same subject appeared in the January, 1995 issue of the Newsletter (see volume 17, no. 1, pp. 19-28.) It seems that a sentence from the introduction to those articles remains true today "This is, obviously, a subject of great concern to conservation and one about which thoughtful professionals have not reached a consensus."

A Discussion of Research on the Effects of Temperature and Relative Humidity on Museum Objects

by Charles S. Tumosa, Marion F. Mecklenburg, David Erhardt, and Mark H. McCormick-Goodhart

Research into the effects of environment (RH and temperature) on materials and structures can be readily divided into three fundamental areas: biological, chemical, and structural. Biological and chemical effects on materials have been studied in great detail since the 19th century. The degradation of proteins, carbohydrates, and other organic materials has been of interest with regard to both the deterioration of materials and industrial processes. That chemical changes are only part of the picture is apparent if one considers that chemically wood and sawdust are equivalent. Clearly structural (mechanical) considerations need to be addressed in defining cultural objects.

From a structural viewpoint, the response of an object to the environment may be divided into several components. First, the materials of the object and how it is assembled; second, the time response of the materials to changes in the environment; third, the damage caused in a changing environment; and fourth, the effects of repeated cycling of the environment. The authors have addressed many of these questions in numerous papers and presentations.

In regard to these points the following observations may be made:

1) The mechanical, physical and dimensional properties of materials are easily determinable, the composite construction of objects is nearly always evident, and the objects as composites can be modelled mathematically. [1]

2) Time effects are dependent upon the diffusion rates, either thermal or moisture.

3) The effects of a changing environment on an object may be considered to be ZERO if the object is the same upon returning to the original environmental conditions. Mechanically, we define this to be when the object exhibits only elastic (reversible) behavior and does not go into a plastic or irreversible mechanical regime. The point at which plastic deformation occurs (the yield point) has been determined for MANY materials to be a strain of at least 0.004, or 0.4% elongation. This is long before actual cracking or breaking of the object occurs. An object may typically experience permanent warping or twisting after experiencing yielding but before physically breaking or cracking. Warped panel paintings are good examples of objects that have experienced plastic deformation without cracking. Warped table tops are also good examples.

4) The effects of repeated cycling within an ELASTIC range, determined by the yield point, have been found to have no structural effect on objects. The equivalence of mechanical and environmental paths to stress development in objects has been shown theoretically and experimentally [2]. Figure 1 shows the effect of the repeated cycling of gelatin (hide glue) for over 5000 cycles. Figure 2 shows the cycling of Pinus sylvestris specimens in the tangential direction. One specimen is of recent origin, the two others date from the 17th century. In these cases there is no change

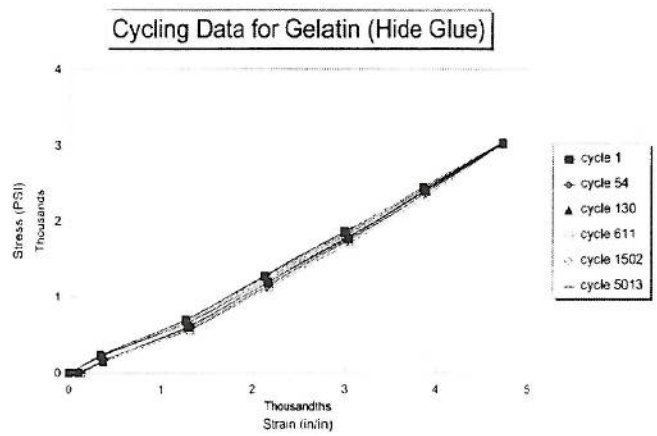

Figure 1 shows the mechanical cycling of gelatin (hide glue) within its elastic region for 5013 cycles. No mechanical damage is discernable.

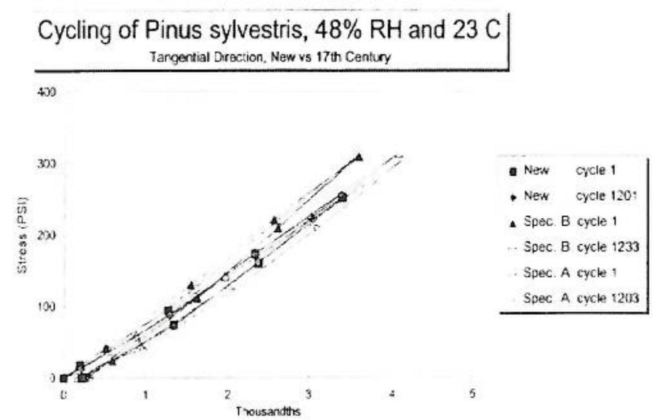

Figure 2 shows the mechanical cycling of three specimens of Pinus sylvestris L., one recent and two others cut in the 17th century. Their behavior in the elastic region is almost identical.

in the structural behavior and little difference between recent and three hundred year old wood specimens [3]. The point here is that since environmental cycling can be shown to be equivalent to mechanical cycling, then one can conclude that some environmentally induced cycling is possible. On the other hand, very large mechanical cycles cause damage rapidly so one concludes that large environmental swings will damage the object. This has been verified experimentally.

The coupling of mechanical information with environmentally induced dimensional responses can be used to determine the appropriate range in which an object can respond to temperature and RH but the component materials are still in the elastic range and do not permanently deform [4]. This approach, in conjunction with chemical and biological data, can be used to determine safe ranges for the exhibition and storage of objects.

The museum environment is, first of all, designed to moderate extremes of temperature and RH and to provide a reasonably tolerable temperature for the staff and visitors (the human comfort zone). This itself can be done by a simple HVAC system with a provision for moisture introduction, usually during cold periods. These simple systems can keep most buildings within a 35% to 65% RH region with the temperature at about 70 deg. F. For control beyond this simple system, further processing of the incoming air is necessary. To lower the RH to 50% RH on a humid summer day, the air must further be cooled (as low as 42° F) to remove water and then reheated to reach the appropriate comfort temperature and desired RH. It requires considerably larger capacity chillers to chill the incoming air and also takes reheat equipment to maintain tighter RH controls. This requires both more energy and more equipment than a very basic system that is allowed to vary seasonally in the range of 35% to 65%. The tighter the control, the more energy and greater system capacity is necessary to quickly return the system to the set point. Other strategies are also possible; for example, using a desiccant system to remove unwanted moisture (which requires the desiccant to be regenerated) etc. No matter how new the system, or how efficient, the thermodynamics dictate that more energy will be used in a tightly controlled single setpoint system than in a system allowed to vary in a given RANGE using multiple setpoints.

Cost savings seem to be an issue in some circles. There are three areas in which savings may be made.

First, it seems that most people now agree that a less stringent set of environmental parameters, i.e. allowing ranges or less tight tolerances around a setpoint, will reduce energy costs.

Second, new construction equipped for a "flatlined environment" will require larger chillers, larger ducts, local electric reheating etc. and MUST cost more. One cannot get more for less in new construction. A new building constructed for a flatlined environment will cost more than a new building constructed for an environment which is allowed to vary within a range.

Third, maintenance costs for buildings with a variable setpoint or allowable range are lower. One of the sources of damage to buildings is water penetration through walls and cracks during the winter. Another source of damage is condensation on windows and their frames. Lowering the inside RH from 50% to between 35% and 40% will eliminate much of the condensation and reduce the moisture penetration problems.

In times of reduced funding, increased environmental awareness, and the need to reduce the wasteful use of limited natural resources, strategies to make museums more efficient should be encouraged. Rigid environmental conditions were a reasonable (if expensive) option when the effects of moderate environmental fluctuations were not clearly understood. Now that we understand the nature and magnitude of these effects, and know that moderate fluctuations can be safe, there are many reasons <u>not</u> to insist on unnecessarily rigid, complex, or expensive environmental control. Implementation of somewhat relaxed environmental recommendations would result in large savings in construction and maintenance, and yield dramatic reductions in the use of energy. Funds are much better spent improving other aspects of collections care and storage, and implementing specialized conditions (such as cold storage) for those materials that require it.

References

1. Mecklenburg, M. F., M. McCormick-Goodhart and C. S. Tumosa, "Investigation into the Deterioration of Paintings and Photographs using Computerized Modeling of Stress Development", <u>J. of the Am. Inst. for Conservation</u>, 55(2): 153-170 (1994).

2. Mecklenburg, M. F. and C. S. Tumosa, "The Relationship of Externally Applied Stresses to Environmentally Induced Stresses", in <u>Fiber Composites in Infrastructure</u>, H. Saadatmanesh and M. R. Ehsani Eds., Proc. of the First International Conference on Composites in Infrastructure, NSF and U. of Arizona, (1996) 956-971.

3. Erhardt, D., Mecklenburg, M. F., Tumosa, C. S. and T. M. Olstad, "New vs Old Wood: Differences and Similarities in Physical, Mechanical, and Chemical Properties". <u>ICOM Preprints</u> (1996) in press.

4. Erhardt, D., M. F. Mecklenburg, C. S. Tumosa and M. McCormick-Goodhart, "The Determination of Allowable RH Fluctuations". <u>WAAC Newsletter</u>, 17(1): 19-23 (1995).

You see, one thing is, I can live with doubt and uncertainty and not knowing. I think it's much more interesting to live not knowing than to have answers which might be wrong. I have approximate answers and possible beliefs and different degrees of certainty about different things, but I'm not absolutely sure of anything and there are many things I don't know anything about, such as whether it means anything to ask why we're here...

I don't have to know an answer. I don't feel frightened by not knowing things, by being lost in a mysterious universe without any purpose, which is the way it really is as far as I can tell. It doesn't frighten me.

Richard Feynman