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# Effects of Relative Humidity Fluctuations on Paper Permanence

*A Data management plan created using the DMPTool*

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## **I. Mandatory for All Projects**

### **I.A. Copyright and Intellectual Property Rights**

#### **I.A.1) Copyright/IP Status**

Intellectual property belongs to Yale University and the Institute for the Preservation of Cultural Heritage. Data will be presented at an NEH meeting and a publication will summarize the findings of the project.

#### **I.A.2) Ownership Rights**

Yale University and the Institute for the Preservation of Cultural Heritage will keep raw data on the computers that were used to generate the data. The conditions of access for outsiders will be that they will need the software required to interact with the data. For instance, for molecular weight data, the software package entitled Empower, which is manufactured by Waters Corporation, will be used to collect the data from the gel permeation chromatograph (GPC). That is a unique, proprietary software designed to run the GPC. In other circumstances, like with the mechanical strength and color data, we can export the data as excel files or as ascii files in order to facilitate data being examined by people that do not have the proprietary software.\n

#### **I.A.3) Privacy/permissions**

If we publish our data in a peer-reviewed journal, often permissions are required by the journal's publisher to hand over the rights of the intellectual property contained within the document to said journal. All non-published data remains the property of Yale, IPCH, and the NEH.

## **IV. For Projects Creating Research Data**

### **IV.1) Summary of purpose**

The goal of this research is to use analytical data to define a relative humidity (RH) range and fluctuation rate that does not cause permanent physical and chemical damage to paper-based objects. This project follows up on an initial study completed in 2001 that examined the degradation of cotton paper when exposed to humidities cycled between 25% – 75% every two hours at room temperature. The next step in that investigation will be exploring in more depth the key factors that may determine the magnitude of risk, paper composition and humidity excursions. The principal activities will be to generate data by exposing three types of paper—a rag paper control, an acidic newsprint, and a modern alkaline book paper—to

fluctuating humidity conditions. Those humidity environments will explore different ranges of excursions—a small one in line with the current definition of “safe,” and a larger one more similar to an environment with little or no humidity control. Tests will also examine the effect of the rate of humidity shift: a rapid one, in which large shear forces may result from wet-dry interfaces within the paper, and a slower shift, which would allow more gradual equilibration that might mitigate the internal shear forces. The molecular weight of the cellulose, as well as the tensile strength and elasticity, color, and moisture content of the tested papers will be measured in order to characterize the stability of paper-based artifacts in these environments. The expected result will be quantifiable evidence of the risk of exposing paper-based artifacts to large and rapid changes in relative humidity.

There are three major reasons why this work will have a significant impact for archives, libraries, and museums. One, it will clarify more precisely the environmental conditions that are necessary to best preserve paper-based artifacts; as recently as 2014, discussion and debate regarding truly safe storage and display conditions for hygroscopic materials was still ongoing. Two, the conditions delineated will be defined by scientific data acquired in laboratory experiments that simulate the storage environments (and are not inferences derived from testing performed at elevated temperatures, for example). Three, the findings of the research will greatly aid sustainability planning, informing the level of climate control that is necessary for collection preservation.

#### **IV.2) Approvals**

The research proposal will be approved for submission by the director of the Institute for the Preservation of Cultural Heritage. The grant submission must also be approved by Yale's Grants and Contracts Administration (GCA). Any participants that act as a PI that do not have professor positions must fill out Yale form 1310 FR.04, PI Status Request, which must be signed by the PI, IPCH director, IPCH's dean or provost, and West Campus department administrator.

#### **IV.3) Privacy**

I don't think there is any PII that requires anonymization

#### **IV.4) Other documentation**

For the final phase, project workers will analyze and report the data collected, disseminate the project results to the target audiences in publications and conference presentations, as well as the archiving of the data for future access, which will be completed according to a data management plan designed by the Institute of Museum and Library Services. This is DMPTOOL but a repository for the raw analytical data must be found.

#### **IV.5) Data collection / generation**

For the second phase, in which the cycling humidity exposures will be completed, samples will be removed from the chambers at various intervals, labelled, and stored for future analysis in a constant environment

chamber that is already in service in the laboratory. This is in accordance with the ASTM standard test method, ASTM D685-12, *Standard Practice for Conditioning Paper and Paper Products for Testing*. This storage period is essential for conditioning papers for uniaxial tensile testing and moisture content measurements. Furthermore, it is more efficient to accumulate a quantity of samples so that analytical tests can be performed all at once. This is particularly critical for gel permeation chromatograph (GPC) measurements of changes to the cellulose molecular weight as the instrument can be difficult with respect to maintaining precision between batches.

Chemical degradation of the cellulose will primarily be evaluated with molecular weight measurements. The molecular weight distribution will be measured using a Perkin Elmer gel permeation chromatograph (GPC), calibrated with pullulan standards, and the weight average molecular weight (Mw) will be calculated using the Empower® software of the instrument. The tensile strength and elasticity of the paper sheets will be measured with an Instron uniaxial tensile tester, and the software system of the instrument's custom software will calculate the strength and Young's modulus (the metric of elasticity). Discoloration will be measured from changes in the visible reflectance spectrum, measured with a reflectance spectrophotometer, which can then allow calculation of the yellowness according to the previously mentioned ASTM standard test method ASTM E313. For moisture content, the weight of the papers before and after being dried in an oven will be recorded by following the previously mentioned TAPPI standard test method T 412 om-11.

#### **IV.6) Metadata and documentation**

Documentation will be raw data from:

gel permeation chromatograph, which can be exported as images since raw data is in a proprietary software format.

uniaxial tensile testing machine (Instron), which can be exported as excel files.

Yellowness Index data, which can be exported as CSV or Excel files.

Moisture content data will be done in an analog format, and photocopies of the logbook data can be made and uploaded to the location where all other data will be stored.

#### **IV.7) Archiving plan**

The dissemination and possible implementation of the results will be made with the consultation of the Yale University Libraries. How best to illustrate, discuss, and summarize the data for, at minimum, the collections managers, librarians, curators, and conservation staff of the Art Gallery, Center for British Arts, Beinecke Rare Book and Manuscript Library, and Peabody Museum of Natural History, is vital. The way data is presented to humanities-focused audience might need a different focus from the way the same exact data would be shared with the scientific community. However, since the goal is to make the information available to collections care officials, it will be important to present the data in a manner meaningful to them. Once the data is shared in-house, we will share the information on a more global scale, at conservation conferences, like the American Institute for the Conservation of Historic and Artistic Works Annual meeting, or at conferences organized by the American Alliance of Museums or the American Library Association. A peer-reviewed publication will be written, although which specific journal it will be submitted to will be decided with assistance of members of the Yale University Library system. In

consideration will be *Studies in Conservation*, the *Journal of the American Institute for the Conservation of Historic and Artistic Works*, and the *Journal of Paper Conservation*. Once the article is published, it will be able to be found via internet or technical article search databases, and therefore the final information will be readily available for anyone interested in the future.

All these data will be recorded in a laboratory notebook that will eventually be archived with all the other laboratory notebooks of the Aging Diagnostics Laboratory, as well as in digital data repositories set up and maintained at IPCH and at Yale. Regarding the long-term storage of the data, results, and samples, there will be several approaches used to ensure that data is accessible after the project is complete. In the instances where data is collected with an analytical instrument – the GPC, Instron, and color data – raw data will be stored in a computer folder that reflects the NEH grant number and project name. Further, data files themselves will be identified by the project name, the data, sample information, number of cycles, humidity range and cycling rate, with all information separated by underscores. Data will be stored with the instrument itself, as software programs attached to those instruments are all proprietary. Copies of the data files will also be stored on a server containing the IPCH science laboratory data archives.

#### **IV. 8) Repository**

Unknown as of 2/25/2016

#### **IV.9) Implementation**

The data management plan and resulting proposal submitted to the National Endowment for the Humanities (NEH) will both be reviewed to make sure that the tasks completed were the same as those promised to the NEH. The NEH monitors progress by hosting a conference and by making end results be explicitly stated in the grant application.