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Folger Sustainable Preservation Environment Project White Paper

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Folger SHAKESPEARE LIBRARY
Advancing knowledge & the arts

NATIONAL ENDOWMENT FOR THE Humanities

Background

Preserving the collection is a critical priority of the Folger Shakespeare Library; "to preserve and enhance its collections" is the opening clause of our mission statement. The Folger is a major center for scholarship, learning, culture, and the arts located in Washington, DC. It is home to the world's largest Shakespeare collection and a primary repository for rare materials from the early modern period (1500–1750). The Folger is an internationally-recognized research library offering advanced scholarly programs in the humanities; an innovator in the preservation of rare materials; a national leader in how Shakespeare is taught in grades K–12; and an award-winning producer of cultural and arts programs—theater, music, poetry, exhibitions, lectures, and family programs. By promoting understanding of Shakespeare and his world, the Folger reminds us of the enduring influence of his works, the formative effects of the Renaissance on our own time, and the power of the written and spoken word. The mission of the Folger Shakespeare Library is to preserve and enhance its collections; to render the collections, in appropriate formats, accessible to scholars; and to advance understanding and appreciation of Shakespeare's writings and of the culture of early modern Europe more generally through various programs designed for all students and for the general public.

The Folger opened in 1932 as a gift to the American people from Henry Clay Folger and Emily Jordan Folger, husband and wife. It is governed by an independent Board of Governors and administered by the Trustees of Amherst College, Henry Folger's alma mater, in accordance with Mr. Folger's bequest. The current annual operating budget is $15.6 million. Last year, visitors to the Folger included 776 readers (for a total of 8,585 reader days); approximately 15,500 exhibition attendees; and nearly 40,000 attendees to the Folger's theater, music, poetry, and lectures programs. More than 12,000 elementary, middle, and high school students and teachers participated in the Folger's education programs, which were held at the Folger, in local schools, and at conferences and workshops across the country. Reference inquiries topped 2,000, and the Folger's website, www.folger.edu, logged millions of visitors. The Folger's staff (including Divisions of Central Library, Education, Public Programs, Research, and Administrative Services as well as Offices of the Director and Development) includes 100 regular full-time, six grant-funded full-time, and thirty-four part-time employees.

The Folger Shakespeare Library's collections include rare printed books, manuscripts, works of art, audiovisual materials, and modern scholarship. These materials extend beyond Shakespeare to include a wide range of disciplines—e.g. history, politics, theology, exploration, law, and the arts—from the early modern period. New acquisitions of rare and modern materials are made regularly through purchases and the generosity of donors. Collection development policy focuses on building existing strengths in order to enhance the collection's value for in-depth research. It is guided by a team consisting of the Folger's Librarian, Head of Acquisitions, Curator of Rare Books, Curator of Manuscripts, Curator of Art & Special Collections, and Head of Reference. The current acquisitions budget is $885,446, and includes funds generated by the Folger's endowment as a whole, funds generated by 28 restricted endowments for acquisitions, and other private gifts supporting current acquisitions initiatives. The Folger has a dedicated book and paper conservation lab with three conservators and two advanced interns. Conservators collaborate closely with curators to determine how to treat particular items, seeking the delicate balance in each case between treating material and preserving its historic integrity.

Overview of the project

Thanks to an NEH Sustaining Cultural Heritage planning grant, the Folger Shakespeare Library has successfully completed phase one of the Folger Sustainable Preservation Environment Project (FSPEP). Phase one of FSPEP provided a solid understanding of the current preservation environment in major areas where the collection is housed long-term, a solid understanding of the climate control systems serving those areas, and practical suggestions for next steps for maintenance and enhancement of that environment without increasing energy consumption (phase two). This project was a collaborative effort of Folger facilities staff, curators, and conservators, guided by the expertise of preservation technology and energy consultants from the Image Permanence Institute (IPI) and Herzog/Wheeler & Associates.

Specifically, phase one of FSPEP conducted a detailed analysis of observed environmental conditions in the Folger's underground vaults (rare book stacks) and New Reading Room (permanent paintings display) over the course of all four seasons of the year. At the same time, the air handler units serving those areas were studied in detail to determine what they were capable of doing, what they were actually doing, and how operational changes and capital improvements to those systems could create a preservation environment as good or better while consuming less energy.

The data collected suggests that through operational changes alone, with no additional capital expenses, the Folger could see a potential annual savings of $22,000 in energy expenses (a 46% savings over as-found costs). This reduction in energy use would not adversely affect the preservation environment. In fact, it would slow chemical decay (natural aging) during the non-dehumidification season (approximately November through April) by taking advantage of the naturally cooler, drier air of DC's winters. Improving the preservation environment in summer would require capital improvements, since the existing mechanical systems as-built cannot provide adequate dehumidification. Energy costs would be somewhat higher after capital improvements because of the extra power required to maintain lower temperature and humidity in summer, but would still be well below the as-found energy costs, and would lead to a greatly improved preservation environment overall.

Methods and standards

At the time most of our air handlers were installed in the early 1980s, it was hoped that they would meet the then-standard year-round preservation targets of 68°F temperature and 50% relative humidity, with minimal daily fluctuations. In practice, this has not been possible, and more recent research shows that the old conventional wisdom is not so wise after all, since the importance of dew point was not recognized. Preservation metrics derived from complex data analysis not possible earlier show that these fixed, narrow targets are overly strict, not necessarily appropriate for library materials, and thus needlessly wasteful of energy and resources (see *Understanding Preservation Metrics* by Doug Nishimura). Accordingly, our goal was to work with our consultants to develop new recommendations appropriate to the Folger's collection and its use, the building envelope, the local climate, and the mechanical systems servicing collection storage areas. Instead of striving for a year-round fixed temperature and humidity target, as was done in the past, we will improve the preservation environment and reduce energy consumption through the gradual adjustment of temperature and humidity set-points twice a year, in November and May (the historic transition points between DC's winter "humidification season" and summer "dehumidification season" when outdoor dew points are approximately 40°F). Previously, it was thought that avoiding temperature and humidity fluctuation was paramount because of the risk of mechanical damage from expansion and contraction. IPI's own research and literature surveys suggest that gradual change twice a year in order to provide excellent conditions in winter, and so-so conditions in summer, is less damaging to the health of library materials over the decades than keeping constant so-so conditions year-round (furthermore, it saves energy by taking advantage of the naturally cooler and drier outdoor air in DC between November and April). The risk of mechanical damage from the twice-yearly shift is more than compensated for by the greatly slowed chemical damage of natural aging. Similarly, although we cannot make our reading rooms considerably colder because of human comfort needs, it is preferable to occasionally move a small number of items from the colder, drier vault to the warmer, more humid reading rooms for use than to keep the entire collection in warmer, more humid conditions all the time (note that because material will never be used in a drier environment than it is stored, risk of physical damage from handling is not a serious issue).

The Preservation Metrics developed by IPI are described below, as excerpted from the Preservation Metrics page at the IPI website:

- Natural aging is quantified by Time Weighted Preservation Index (TWPI) values. These single figures represent the rate of spontaneous chemical change in organic materials (the paper, textiles, leather, etc. that make up the collection) as estimated from the cumulative effect of temperature and relative humidity as they change over time. TWPI is calculated from the Preservation Index (PI) points recorded every half hour by the PEM2 data loggers (each recorded PI point is an average of six temperature and relative humidity readings taken at 5-minute intervals during the previous half hour). TWPI is "time weighted" because the more time an object spends in a space with a higher PI, the better. The preservation index number can be thought of as the number of years a theoretical very-sensitive object could be stored in that space before significant damage. A TWPI of 45 or lower ranks as "risk," 45 to 75 as "OK" and 75 or higher as "Good." All organic materials decay over time. Our goal is to slow the decay rate as much as possible.

- The risk of mechanical damage is determined by three different aspects of moisture content: Maximum Equilibrium Moisture Content (i.e., Is it too damp? Will paper curl? Will emulsions soften? Will wood warp?), Minimum Equilibrium Moisture Content (Is it too dry? Will paper become brittle? Will emulsions crack? Will wood chip?), and Dimensional Change (How great are the fluctuations between the most damp and the most dry? Has expansion and contraction from absorption/desorption of water put physical stress on the collection materials?).

- Metal corrosion risk is determined by the Maximum Equilibrium Moisture Content (EMC Max), a representation of how much moisture is present in the air. The lower the number, the better. In addition to obvious examples of metal in the Folger collection (e.g., steel swords used by famous 19th-century Shakespearian actors, Renaissance bindings with metal clasps) the high iron content of writing and drawing ink in the early modern period puts large sections of the manuscript and art collections at risk from corrosion.

- The Mold Risk Factor (MRF) measures the risk for growth of the xerophilic mold species (fungi that do not require free water for growth) on collection objects or in collection areas. Mold spores exist everywhere, but only under certain temperature and humidity conditions will the spores be able to germinate. A mold risk factor between 0.5 and 1.0 indicates that mold spores are half way or more to germination, meaning half way or more to a vegetative mold state. A mold risk factor greater than 1.0 indicates that mold spores have germinated, entering a vegetative mold state and visible mold could be actively growing.

Project activities

Preparation

In December 2008, we began collecting temperature and relative humidity data with PEM2 dataloggers in order to have a machine-readable dataset (previously, we'd been using drum-style recording hygrothermographs). Certain loggers were identified for daily uploads to PEMdata.org, a free online data analysis tool provided by IPI, the other loggers are uploaded monthly or quarterly. If a daily upload shows anomalous data, the remaining loggers in spaces served by the same air handler are checked for confirmation. It was vital to have at least one full year of data before the start of the project in order to be able to know current preservation conditions and be able to compare them with experimental operational changes made during the grant.

Metrics from the PEM2 dataloggers in areas where collection materials are permanently stored indicated that environmental conditions were not optimal for long-term collection preservation. In terms of damage to collection material from natural aging, mechanical damage, and metal corrosion, all major long-term collection storage areas were in the "risk" zone or at the low end of "OK" (of three possible ratings: Good, OK, and Risk). In addition, the east end of the Deck C vault earned a "risk" ranking for mold growth (there is no OK rating for Mold Risk Factor, only Good and Risk. At a MRF of 0.5, conditions are appropriate for germination of spores, so the "Risk" alert warns of the potential of mold growth before any visible or vegetative mold will appear. This allows for time to react and prevent formation of vegetative mold).

Site Visits and Data Collection

Led by Jeremy Linden of IPI, our consultants made three site visits to the Folger, a three-day visit at the start of the grant period, a two-day one in the middle, and a wrap-up two-day visit at the end. Throughout, they stayed in close communication with Folger project team members, making sure that everyone understood the project's objectives and methods. In particular, they spent time with David Conine (Facility Manager, representing Facilities) and Erin Blake (Curator of Art & Special Collections, representing Collections). David and Erin literally shadowed the consultants as they gathered data on mechanical systems, examined the collection spaces, and placed data loggers within the air handler units targeted for study. This proved an invaluable opportunity for everyone to share information about the collection, the building, the mechanical systems, and new understandings of the preservation environment.

In all, sixteen PEM2 dataloggers were installed inside four air handler units in order to record the temperature and humidity of air as it moves through each stage in the system (supply to the unit, post cooling coil, post heating coil, supply to the room, return from the room, and mixed supply and return). Monthly data uploads to PEMdata.org were integrated into the existing routine for monitoring PEM2 loggers in collection spaces. At the same time, David Conine began a log of any known events that could show up as unusual data in the monthly uploads (e.g. equipment breakdowns, steam stoppages) and e-mailed the list to Jeremy Linden at IPI on the same monthly schedule.

Experimental Overnight Shut-downs

During the second site visit, Jeremy Linden and Jim Reilly of IPI reviewed data collected to date with the project team and proposed nightly shut-downs of two air handler units—AHU 1 and AHU 5—as a closely-monitored energy-saving experiment.

The decision to experiment with nightly shut-downs was not taken lightly, as these units serve the spaces that house the bulk of the library's rare materials: the Deck C Vault, the Art Vault, and the STC Vault. Several factors convinced us the experiment was likely to succeed. As explained in the IPI–Herzog/Wheeler report:

> Deck C is almost entirely surrounded by earth, two floors below grade, providing an excellent buffer from overnight temperature changes (all four sides and the floor are insulated by the ground; the ceiling is insulated by the conditioned space directly above, which is itself one floor below grade)
>
> The Art and STC vaults are entirely surrounded by conditioned spaces except for a small portion of the ceilings of each, which are topped by approximately four feet of earth.
>
> During normal daily operation, Deck C showed relatively little temperature gain: air pulled back into the return was 4 to 5°F warmer than air supplied to the room, indicating there was little heat load during the day, when the space is semi-occupied, with one or two computers running, and additional lights on; overnight, the space is unoccupied, computers are off, and only emergency lights are on.
>
> The Art and STC vaults showed even less temperature gain during normal daily operation: less than 2°F

Encouraged by this data, we began experimental overnight shut-downs of AHU 1 and 5 on May 2, 2011. At first, we tried an 8-hour shut down of AHU 1 and a 6-hour shut-down of AHU 5. After comparing results, we later switched to an 8-hour shut-down of both without adverse effect. Again quoting from the IPI–Herzog/Wheeler report:

> ...temperature variation ... during the shutdown has shown, on average, a temperature increase of between 0.5°F and 1°F, which the system is able to recover, the space returning to setpoint temperature, the following day within two hours. There has been no cumulative temperature increase in the space during the experiment due to the shutdown process.... Achieving these results during the high heat and moisture summer season of the Washington, DC, metro region indicates that this operation adjustment should be able to be run on a year-round basis, with no meaningful impact on the preservation environment, while saving on energy costs. ... RH levels fluctuated by up to 5% ... during the nightly shutdown experiment. This is due to two factors – the change in dew point in the space during the shutdown and, to a lesser extent, the slight fluctuation in temperature.

> Both the dew point and the temperature are recovered within the first two hours of the system coming back on, and the RH adjusts with that recovery. This fluctuation actually has very little bearing on the overall preservation of the collection. Past IPI research has shown that it can take up to 30 days for collections materials to fully equilibrate to a change in moisture content in the environment – in other words, that 5% change in RH would have to stay constant for 30 days before collections materials completely equilibrated to the new condition. These fluctuations, occurring over the period of eight hour shutdown and then recovering, are not of a long enough duration to cause change in the material. In essence, due to the slow rate of moisture equilibration, these small, short-term fluctuations are not felt by the collection.

Based on the experiment, we have continued the nightly shut-downs, and of course continue to monitor the spaces with PEM2 dataloggers. As it is only November, we have yet to collect data from the winter season. We will be particularly alert for large, cumulative, or unrecoverable drops in relative humidity over the coming months.

Wrap-up

During the final site visit, Jeremy Linden and Jim Reilly of IPI reviewed the preliminary data findings with David and Erin, then met with the project team as a whole to discuss likely scenarios for seasonal adjustments and future capital improvements. Because the potential seasonal temperature adjustments for the underground vaults would make the space much colder than current temperatures (going from 65°F to 50°F), the group also met with the Head of Reader Services and the Head of Circulation to discuss the reasons for the recommendations. Their staff would be heavily affected by a 15°F temperature change, so it was essential to have their support. in make in slowing the natural aging of the collection.

Final results

The project achieved all of its goals: we now have a solid understanding of the preservation environment in the underground vaults and the New Reading Room (major areas where the collection is housed long-term), a solid understanding of the climate control systems serving those areas, and practical suggestions for next steps for maintenance and enhancement of that environment without increasing energy consumption. The study also revealed instances of excessive energy consumption: some systems were sub-cooling and reheating air year-round instead of only in summer (when sub-cool and reheat is needed for dehumidification).

We are implementing all the operational changes in the report:

- AHU 4 (supplies pre-conditioned air to the AHUs serving the underground vaults)
  - restrict winter (November–April) heating to the minimum necessary to avoid freezing of the coils in the unit
- AHU 1 (sends pre-conditioned air from AHU 4 to the Deck C vault, which houses the bulk of the Folger's rare material)
  - correct the year-round sub-cool/reheat operation to only sub-cooling when dehumidification is necessary (May–October)
  - run an 8-hour shutdown of the system nightly
  - enact winter, non-dehumidification season (November–April) setpoints of 60°F and 35–40% RH (reducing the temperature to 50°F in winter, as recommended, depends on capital improvements)

- AHU 5 (sends pre-conditioned air from AHU4 to the Art Vault and STC Vault)
    - correct the excessive winter sub-cooling and reheating to do only necessary sensible cooling (roughly November–April)
    - run an 8-hour shutdown of the system nightly
    - enact winter, non-dehumidification season (November–April) setpoints of 60°F and 35–40% RH (reducing the temperature to 50°F in winter, as recommended, depends on capital improvements)
    - leave the total bypass damper closed

Note that there were no operational changes recommended for AHU 15 (serves the New Reading Room and Service Vault) as it is incapable of providing an “OK” or “Good” preservation environment without capital improvements.

The report recommended four capital improvements:

1. Install a booster chiller with glycol and redesign the cooling coil at AHU 4 to allow for lower summer dew points in the underground vaults.
2. Redesign AHU 15 [and AHU 14, its twin and partner] to allow for better summer dew point control based on a sub-cool and reheat system.
3. Explore cost of creating steam on-site.
4. Upgrade and calibrate control system temperature/relative humidity sensors in all collections areas and air handling units serving collections areas.

Recommendations #1 and #2 are the subject of a 2011 NEH Sustaining Cultural Heritage Collections Implementation Grant application.

Recommendation #3 has already been implemented in as much as our brief exploration of creating steam on-site quickly revealed that it was preferable to continue purchasing (expensive) steam from the Architect of the Capitol.[1] Leaving aside the cost of equipment and personnel, our property simply does not have the necessary space for the equipment.

Recommendation #4, to upgrade and calibrate control system temperature/relative humidity sensors, is well underway, independent of the grant application. In addition, we plan to install airflow sensors, to alert us if a filter goes bad sooner than expected. We determined during the course of the planning grant that upgrading and calibrating the sensors in all collections areas and air handling units serving collections areas was critical to implementing the necessary operational changes, and that for the sake of the collection we could not delay.

To summarize, phase one of the Folger Sustainable Preservation Environment Project revealed that through a combination of operational changes and targeted capital improvements, it is possible to greatly improve the preservation climate in the Deck C Vault, Art Vault, and STC Vault, and more moderately improve the preservation climate in the New Reading Room and adjoining Service Vault, while decreasing overall energy use. (Note that greater improvement is

[1] The Architect of the Capitol (AOC) is the federal agency responsible for maintenance, operation, development, and preservation the Capitol complex. Although the Folger is a private institution, our location on Capitol Hill means that the building is served by the same chilled water system as the Supreme Court, Library of Congress, US Capitol, and other near-by federal buildings

not possible in the New Reading Room because it must accommodate sedentary workers, so cannot be kept colder than 68-70°F). Operational changes alone, without capital improvements, could see energy expenses reduced by 46% and winter conditions in the underground vaults improved from a Preservation Index of 85 to a Preservation Index of 125, slowing chemical decay (natural aging) by more than a third.

Evaluation

Phase one of FSPEP came at a fortuitous time for the Folger: because a new facilities manager was just starting when the project began, the importance of a sustainable preservation environment was a constant as he familiarized himself with the library's mechanical systems, as was working with a representative of the collection care team. At the same time, because of the FSPEP site visits, a representative of the collection care team spent days climbing in and out of air handler units while learning about cooling coils, reheats, and why it was difficult or even impossible to achieve certain conditions with some equipment. One of our fears going into the project was the danger that an adversarial relationship could develop, but instead the opposite happened. Thanks to their shared professionalism and dedication to the Folger's mission, and the encouragement from our consultants, particularly Jeremy Linden of IPI, the project brought David and Erin together as colleagues in good humor. The two of them regularly consult each other on issues outside this project where collection care and facilities intersect. Easy and open communication between the facilities side and the collections side of the operation is without doubt one of the most important and most overlooked factors in sustaining an optimal preservation environment.

The project had only two weaknesses, the first of which has been addressed by changes to the grant program. Planning grant recipients are now able to apply for an additional $10,000 to carry out one or more recommendations made during the course of the project. By the time of the second site visit from our consultants, it was clear that we could not move attempt the experimental overnight shut-downs without replacing sensors and controls. (One of the important lessons from the project: if the computer display shows anomalous data, don't believe it until you've walked the system. Open up the side of the AHU to verify the coil temperature with an IR gun, and verify the presence of a humidifier vapor trail with a flashlight). Fortunately, we were able to move forward with the replacement of certain key sensors and the installation of an FX Server control system. The second weakness was simply one of timing. Because we needed to make sure we gathered test data during the summer, when the system is most stressed, we were pressed to get the consultants' report completed and reviewed in time to turn it around for an implementation grant application.

Continuation of the project and long-term impact

We are submitting a 2011 NEH Sustaining Cultural Heritage Collections Implementation Grant application in order to be able to implement capital improvements #1 and #2, as recommended in the consultants' report. As mentioned above, we have already implemented overnight shut-downs, and will continue to monitor them closely. Recently, we successfully extended the energy-saving overnight shut-downs to AHU 2, which serves the Deck B Reference stacks. Deck B reference is an underground space configured identically to the Deck C vault and, like it, is unoccupied with little load overnight.

As the recommended changes are implemented, the Folger Sustainable Preservation Environment Project will transition into the Folger Sustainable Preservation Environment Program, a normal part of routine operations with a representative from the facilities staff and a representative from the collection care staff working together to keep the process going. David and Erin both have access to both monitoring systems (PEMdata.org for detailed information about the preservation environment over time in various locations in the building; FX Server for detailed information about mechanical systems in real time and historically).

Lessons learned from the study are now being applied to other systems in the building, notably AHU 6, serving the Paster Reading Room, and AHU 7, serving the Exhibition Hall. On a much greater time-scale, the long-term impact of this project will be felt by the collection, thanks to the greatly slowed rate of chemical decay, and by the environment, thanks to reduced energy consumption.