



Paper Permanence

Paper permanence—the stability of paper and maintenance of its initial properties over a lengthy time—can be measured by accelerated aging tests in the laboratory. Such aging can then be correlated with long-term natural aging.

Several factors determine the lifespan of paper. For example, it has been observed that alkaline papers (pH 7.5 to 9.5) have a longer life than do acid papers (pH < 7.0). However, the roles of other paper-aging factors like pollution, heat, humidity, and exposure to light have not been well studied. Such is also the case for paper fibers that contain lignin—a component of wood. Does the presence of lignin make paper less permanent? The role of lignin in paper permanence has come under renewed scrutiny in light of the paper industry's interest in setting the standards for permanent papers differently, which is on the basis of paper performance rather than paper composition.

Although the general public will benefit from more stable paper, primary beneficiaries of research on paper permanence are archivists and librarians who collect and preserve paper documents. Under normal use and storage conditions in libraries and archives, stored paper should not deteriorate significantly for hundreds of years. Replacement of degraded papers by microfilming or digitizing is an option, but it can be expensive and has serious limitations.

Background

A high-quality test to predict paper stability over time has not been available. Therefore, the Paper and Paper Products Committee of the American Society for Testing and Materials (ASTM) was interested in developing test methods for this purpose. In 1994, a workshop was held in Philadelphia, PA, with the objective of developing a program of research on paper stability over time that would lead to

- credible, reliable, accelerated aging testing protocol,
- life expectancy for any reasonable paper composition, and
- chemical and physical mechanisms of aging.

With these objectives, a request for research proposals was sent to 25 institutions worldwide and 5 were chosen to do the research. The USDA Forest Service, Forest Products Laboratory (FPL), and the Finnish Pulp and Paper Research Institute, Espoo, Finland, were chosen to do research on credible, reliable, accelerated light aging test methods of paper. Others were chosen for research on pollutant and thermal aging.

Objective

The objective of the ASTM-funded research program was to develop a scientifically valid protocol for an accelerated light aging test method that would predict natural aging behavior of papers. There were 15 different composition papers specifically prepared for the ASTM program.

Approach

Light aging was carried out in two different environments. In one environment, a simulation of normal aging under typical conditions was carried out with exposure to both artificial (halogen and fluorescent) and daylight illumination. This was called natural aging.

In the other environment, aging was carried out at an accelerated pace; papers were exposed to light from a 1000 W xenon arc lamp. Effects of various factors such as photon flux, temperature, gaseous atmosphere, and humidity were also studied.



Paper permanence study, showing aging of papers in daylight, north-facing window.



Under this project and for the next 100 years, all 15 papers will be stored in 10 North American libraries in a variety of climates. The libraries will periodically submit a storage condition report to the U.S. Library of Congress and the National Archives and Records Administration. At 10 intervals during the century-long storage, papers sheets will be removed and tested for optical and physical properties. Results will be shared worldwide.

Research in both the natural and accelerated environments included monitoring the changes in optical and mechanical properties. By comparing the effects of light aging in the two environments, methods for an accelerated aging protocol were developed.

Outcomes

- Detailed knowledge was obtained about the chemical changes that take place when papers of different composition are exposed to light.
- Methods were developed for an accelerated light aging test that would predict natural aging behavior of paper.
- A test method for accelerated light aging of paper was proposed to ASTM and was accepted and published by ASTM D6789-02.
- The accelerated light aging test method can be used to obtain information on the relative stability of optical properties of a paper over time.
- The 100-year natural aging project will be used to validate the reliability of the accelerated paper aging test methods.