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A Low-Oxygen Capable Storage and Display Case for the Proclamation of the Constitution Act

In memory of Shin Maekawa

ABSTRACT

Library and Archives Canada (LAC) holds the two original copies of the Proclamation of the Constitution Act, 1982 in the collection. One was signed outdoors and exposed to water droplets, and subsequently became known as the 'Rain Drop' copy. The second was signed indoors; however, it later suffered intentional damage from an activist in 1983. This copy is described as the 'Red Paint' or 'Red Stain' copy. Microfade testing conducted in 2011 by the Canadian Conservation Institute (CCI), concluded that the signature inks used on both copies are highly light sensitive. This information, coupled with an increasing demand for the long-term display and loan of the objects, compelled LAC to collaborate with CCI on the design of a pair of custom storage cases. The enclosures were specifically developed with the capability of maintaining low oxygen conditions for the duration of a typical loan, since the technique has shown promise for slowing the fading rate of many light-sensitive colourants.

The broader project included several sub-components: design and construction of the sealed inner display case (or storage case); design of a document mounting system suitable for display and transportation; and procurement of a specialized outer case that addressed additional functional requirements. These elements are described in the context of a loan that prompted rapid completion of the work. The results of preliminary lightfastness testing of fountain pen inks are also presented.

BACKGROUND

The Proclamation of the Constitution Act, 1982 is an extremely important document for all Canadians. It signifies Canada's evolution from colony to independent nation. The Proclamation brought into force the act that gave Canada the power to make changes to its own constitution, and also entrenched a Charter of Rights and Freedoms.

One copy was signed by Queen Elizabeth II during a ceremony on Parliament Hill on a rainy April day in 1982, and suffered light water damage. This copy is unofficially referred to as the 'Rain Drop' version. The other was signed privately indoors, later suffered intentional damage by a protestor, and has become known as the 'Red Stain' version. Library and Archives Canada holds both versions of the Proclamation in the collection.

This article details the successful collaboration between LAC and CCI to design and fabricate two custom storage cases to safely protect and house these important documents. A brief history of the Proclamation is also outlined for context.

VANDALISM

A little over fifteen months after the signing of both copies of the Proclamation, the pristine copy (signed indoors) was intentionally damaged. In 1983, 24-year-old Peter Greyson entered the National Archives building in Ottawa, posing as an art student conducting research on the design and calligraphy of the Proclamation. James Whalen, then archivist and custodian for the document, later wrote,

> As the well-dressed and polite art student had properly identified himself and appeared to be a legitimate researcher, I had no reason not to trust him and retrieved the Proclamation from storage. (Whalen 2006, 291)

Greyson asked to be left alone to study the document, but his request was refused. He began leaning over, and suddenly there was a red substance spreading out over the document. The liquid had been hidden inside Greyson's suit coat pocket and it was later found to be red paint that came from a small "Elmer Safety Glue" container. Later in court, Greyson testified that he was protesting against Prime Minister Pierre

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Trudeau's decision to allow the United States to test cruise missiles over Canadian air space. Greyson stated that he believed this was a violation of his rights under the new Canadian Charter of Rights and Freedoms (Whalen 2006, 293). The previously undamaged copy subsequently became known as the Red Stain version.

TREATMENT CONSIDERATIONS

The conservation labs were fortunately located in the same building at the time of the incident, and went into immediate action. Conservators began by attempting to remove as much paint as possible through suction; however, due to the nature of the paper (hand-laid Manitoba Flax), the paint was quickly absorbed leaving the document permanently stained.

Over the next few months, different tests and analyses were carried out and various treatment options were considered: chemical destruction of pigments; photo-chemical bleaching; laser cleaning technology; and physically altering the document (removing and replacing the stained area). On December 9, 1983, in a letter to W.J. Kozar (Director General, Canadian Conservation Institute), K.F. Foster, (Director General, Conservation and Technical Services, National Archives of Canada), summarized the lack of progress to-date:

> The present situation offers a difficult conservation problem, recognizing that the paint is lead-based and inert, we are presented with a problem against which no conventional conservation process has proved effective. We would appreciate it if your staff could review the reports and offer any advice they think might be helpful in this matter. (Foster, 1983)

Eventually, after many months of testing and weighing of options, then Dominion Archivist, Dr. Wilfred I. Smith made the decision that the stain should be left. The vandalism had become part of the history of the document, and any attempts to alter or replace portions of the document would affect its authenticity and integrity (Whalen 2006, 295). This incident had long-term effects on access and security procedures for prestigious documents at LAC and factored heavily into the design of both new storage cases.

EXHIBITION HISTORY

The two copies of the Proclamation have been exhibited extensively since 1982, and their popularity as exhibit items often led to discussions over the cumulative effects of exposure to light. From 1987 to 1998, both copies were alternately displayed every July 1st at 395 Wellington Street in Ottawa. In 2000, both versions were on display in the Hall of Honour on Parliament Hill for a period of five months. This was followed by a loan of the Rain Drop copy to the Royal Ontario Museum in 2008. In September 2014, the Rain Drop copy was loaned to the Canadian Museum for Human Rights (CMHR). The timeframe for the loan to the CMHR created the deadline for the completion of work described in this paper.

It is difficult to estimate the total cumulative light dose for each document since accurate data regarding lux levels and duration of past exhibits were not always recorded. From the information available, a conservative estimate of total exposure to date (calculated prior to the most recent loan of the raindrop copy to CMHR) amounts to approximately 4,000 hours of display for each document at varying lux levels and light sources. This information, along with the results of microfade testing on the signature inks (indicating that they continue to be at risk of fading), underscored the urgency to fabricate a custom storage case and a secure display case prior to the loan of the Rain Drop copy to the CMHR.

LIGHTFASTNESS EXPERIMENTS

MICROFADE TESTING OF THE DOCUMENT SIGNATURES

Microfade testing (MFT) (Whitmore, Bailie and Connors, 2000) was performed on the document signatures in 2011 by scientists from the Canadian Conservation Institute (Tse and Begin, 2013) to determine their sensitivity to light fading. The test results indicated that the synthetic dyes in the fountain pen inks used to sign the documents were highly light sensitive, and correspond to Blue Wool (BW) ratings in the range of BW1 to BW3. As a result of this finding, it was evident that the signatures were at risk of significant fading if the documents continued to be displayed as frequently as they had been in the past. Due to the fugitive nature of the inks, and high demand for exhibiting the documents, the benefits of a low-oxygen case were investigated. This was considered in parallel with conventional approaches for mitigating light damage in a museum setting.

TESTS ON PREPARED INK SAMPLES

In a second phase of the lightfastness analyses, experiments were performed on prepared ink samples to allow for greater flexibility with test conditions (Hagan and Tse, 2013). An ink cartridge was available at LAC that was believed to contain ink from a pen used at the ceremony in 1982 (labelled Cross black). Analysis of the reflectance spectra suggested that the ink was not identical to any of the signatures; however, it was still used for comparative measurements. In order to investigate the potential benefits of low oxygen for slowing the rate of fading, a custom test cell was constructed. Figure 1 shows the machined aluminum block with gas fittings for entry and exit of the control gas. A sealed window made from low-iron, anti-reflective, glass provides access to the sample for MFT measurements within the controlled environment.

Samples from the ink cartridge were tested on writing paper, and also as separated components on chromatography paper. Results showed a small improvement of lightfastness

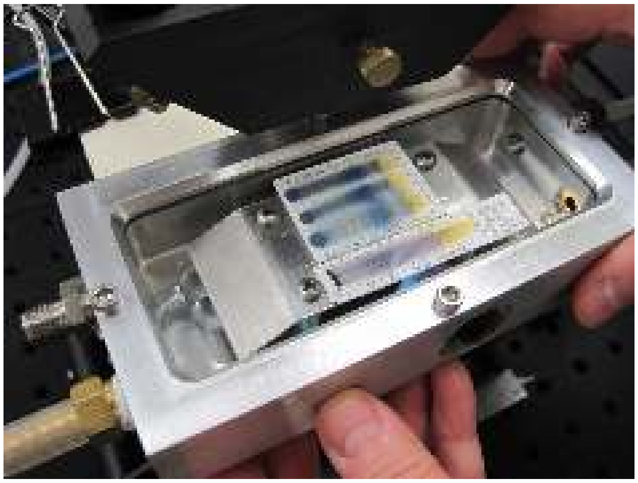

Fig. 1. Enclosure constructed for performing microfade tests under controlled oxygen and relative humidity conditions. Image shows testing of a chromatographic separation of a black fountain pen ink.

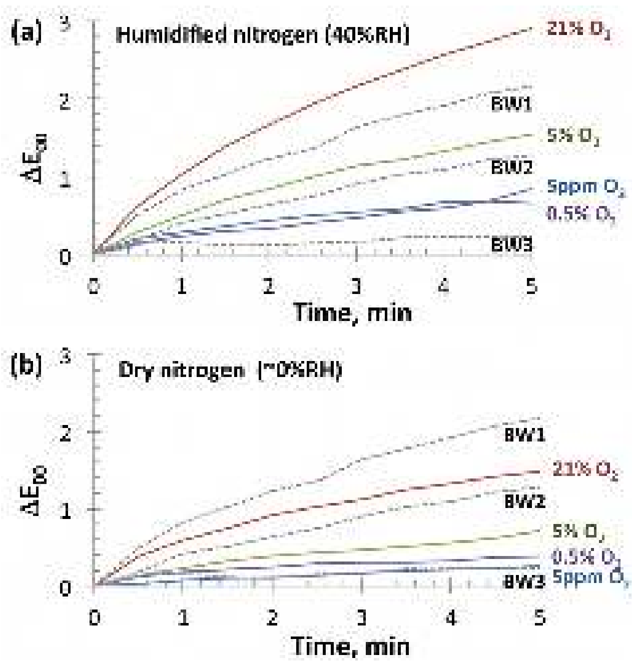

Fig. 2. Microfade test results from a purple component of a black fountain pen ink under varied oxygen concentrations: (a) 40% RH wit; (b) 0% RH. Results shown relative to ambient Blue Wool data.

for the whole ink under low oxygen, and higher improvement for a separated fugitive component. Figure 2a shows the results from testing a fugitive violet component of the ink exposed at 40% relative humidity, and varied oxygen levels. Lowering the oxygen concentration decreased the rate of fading—particularly down to the 0.5% condition. Figure 2b presents data from a similar set of tests using dry nitrogen gas. These results indicate that relative humidity also has an

Fig. 3. Image of 14 dye-based fountain pen inks unexposed to light, and exposed to a dose of 20 Mlx·h. Sample ink strokes were prepared on buffered paper with a broad 3 mm wide fountain pen nib.

effect on the fading rate of the colourant. Unfortunately, this benefit cannot be fully capitalized since an extremely low moisture content would cause deformations and stresses between bonded materials.

A series of conventional lightfastness tests were also performed on strokes of fountain pen inks using light-boxes with a custom-built enclosure to provide separated zones with ambient and anoxic conditions. Figure 3 shows an image of 14 black dye-based writing inks that were exposed to a light dose of 20 Mega lux hours (Mlx·h) at approximately 20klx. The experiments showed that writing inks are typically in the Blue Wool 2-3 lightfastness category (highly fugitive). These unsuitable products can be avoided by selecting pigmented inks; however, they are typically a special order and lack availability at local office suppliers. Results from the low oxygen experiments indicated little to no visible change of the inks at the same dose.

CASE DESIGN

Funding for the project was approved in 2013, and it was determined that the deliverables would include the construction of two storage cases built to meet the specifications provided to the supplier by LAC. The functional requirements were considered at the onset, and several design specifications and limiting factors were outlined:

- Leakage: hermetically sealed with a leakage rate sufficiently low to permit low oxygen display.
- Glazing: forced entry resistant, UV filtering, anti-reflective and low-iron content.

- Stability: construction involving relatively inert materials, suitable for long-term object display.
- Illumination: control and monitoring of light levels.
- Practicalities: modest budget, short time-frame for delivery (constrained by an upcoming loan).

After reviewing close to a decade of previous research that had been performed at LAC on preservation and display requirements for these documents, the decision was made to segregate the preservation specifications from the majority of the security specifications. The rationale for this separation was that it was not necessary to have a high forced-entry rating for the storage case since it would be primarily located in a secure vault. Instead, the storage cases were designed to address preservation concerns, and to fit seamlessly inside a separate display case that addressed the bulk of the security and lighting requirements during exhibition periods.

This decision would lead to the creation of two separate projects, one for the two storage cases and one for a single custom display case built to accommodate either of the storage cases. Drawing inspiration from the custom cases built by other institutions (National Bureau of Standards 1951; Maekawa 1999; Robinson 2011), LAC and CCI began a collaborative project to design the cases and coordinate their manufacture through local fabricators.

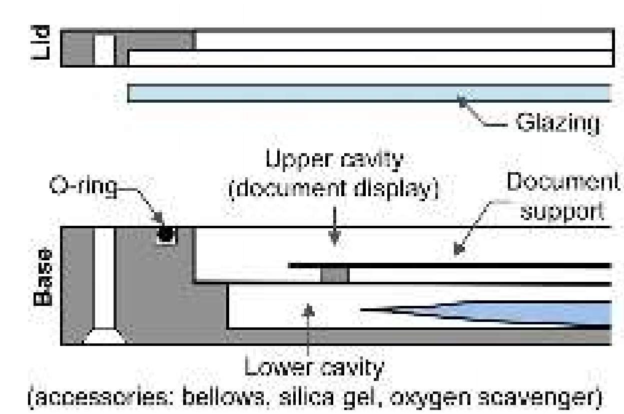

Fig. 4. Simplified cross-section of the case design showing the lid, glazing, and base components.

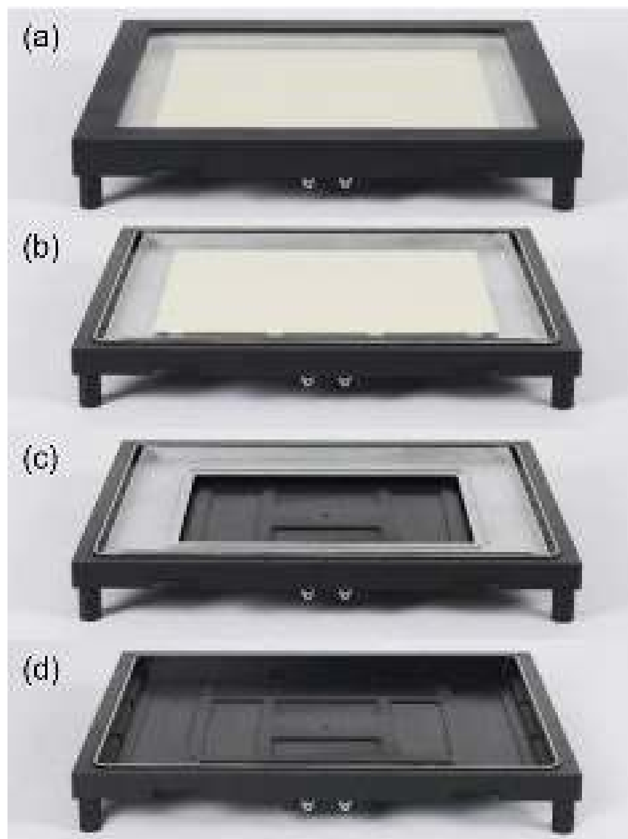

Fig. 5. Images showing disassembly of the case components: (a) complete assembly; (b) lid removed; (c) document support plate removed; (d) base only.

STORAGE CASE (INNER CASE)

The design for the storage case was developed through consideration of related work from the Getty Conservation Institute (GCI) (Maekawa 1999; Beltran, Druzik and Maekawa 2012), Tate (Lerwill, et al 2015), and the National Institute of Standards and Technology (NIST) (National Bureau of Standards 1951; Robinson 2011) in the U.S. This included developments in low-oxygen case design, and also materials testing to determine the benefits and risks of displaying objects under such an environment.

After consideration of design options, it was determined that it was feasible to construct a low-oxygen capable case within the project budget. A solid model was constructed in computer-aided design (CAD) software for the various components, which was then passed to the fabricator for manufacture. Due to the slim profile of the object, it was practical to machine the lid and base from solid aluminum billets. Machining included several tooling stages: cavities in the blocks (document display, accessory compartment and glazing recess), holes for fasteners and gas fittings, and o-ring grooves. Figure 4 shows a simplified cross-section schematic of the primary assembled components. The lid has a machined cavity, a recessed slot for the glazing, and threaded holes for the perimeter fasteners applied from the base underside. The base has a two-step machined cavity for the document display chamber (top), and storage of accessories (bottom). Accessories included the bellows, conditioned silica gel, and activated carbon.

Figure 5 shows four images of the case that were taken prior to final anodizing of the inner metal components: (a) complete assembly; (b) lid removed; (c) document support plate removed; (d) base only. The lid is removed with detachable handles, and the inner document mounting plate is a separate assembly that is removable from the central support plate that separates the viewing chamber from the accessory cavity below (compare Fig. 5b and 5c). In Figure 5d, the base is shown alone with the detachable feet that allow for flexible mounting options within the final display environment. Gas fitting connections are located on the front underside for easy access, while concealed from view.

The completed base assembly was also fitted with a partially inflated bag (bellows) made from heat-sealed aluminized film (Marvelseal). The bellows is connected to a small hole situated underneath the case, venting to the outside environment. This safety feature allows the bag to change size and avoid a pressure differential between the case and the outer environment. Such a situation may occur due to barometric pressure fluctuations, or temperature changes from the condition when the case is initially sealed. The volume of the bellows was not designed to accommodate pressure changes that may occur during air travel; therefore, transportation is restricted to ground travel while sealed (unless special modifications are made). Figure 6a shows the base of the case with the bellows, while Figure 6b shows the underside with the tubing, gas fittings, mounting bracket, and central vent.

An important aspect of the project that required considerable attention was the way in which the document was mounted inside the case. After much discussion, it was decided to physically secure the document around the perimeter as discretely as possible. A custom clip design was developed that uses magnets to hold them in place at predefined points around the perimeter. Figure 7 shows a schematic of the clip design and associated components. The clip was made from steel (magnetic) and formed into a C-shape with a slight hook on the lower end. After assembly, the magnet holds the clip against the lower surface, and the hook prevents the clip from sliding out from the plate. The machined recess on the underside of the plate also prevents the clip from translating side to side. In order to provide gentle pressure against the document, a film of Mylar was formed to fit inside the clip, and overhang slightly onto the document surface. The top surface of the Mylar was roughened with 400-grit sandpaper to reduce reflections, while still providing transparency since it was directly against the document.

Transportation of the case with the object installed raised concerns about how well the assembled components were secured. Several precautionary measures were added to the design in order to provide additional restraint. Small shims of paper, of equal thickness to the document, were attached to the mat board layer at each clip location. These were used to prevent rotation and shifting of the document, and also ensure that the Mylar remained flat along the top surface. When the document plate was secured within the case from the underside, a perimeter of raised metal bars prevented any additional

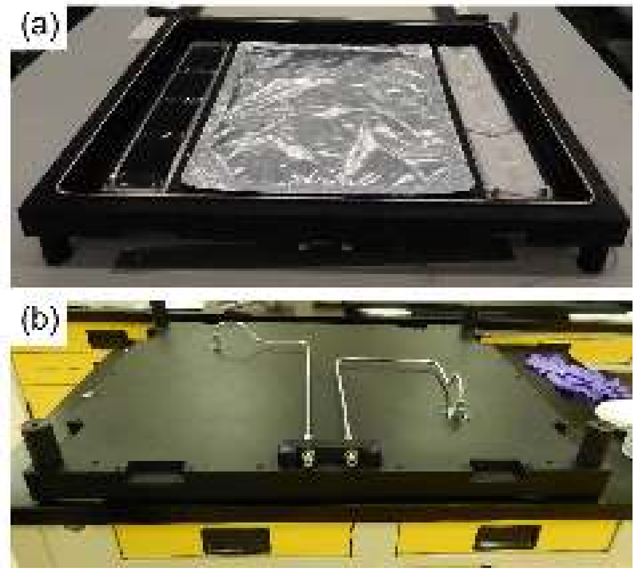

Fig. 6. Images of the base with added accessories: a. top view with bellows activated carbon and silica gel; b. bottom view with tubing, gas fittings and mounting bracket.

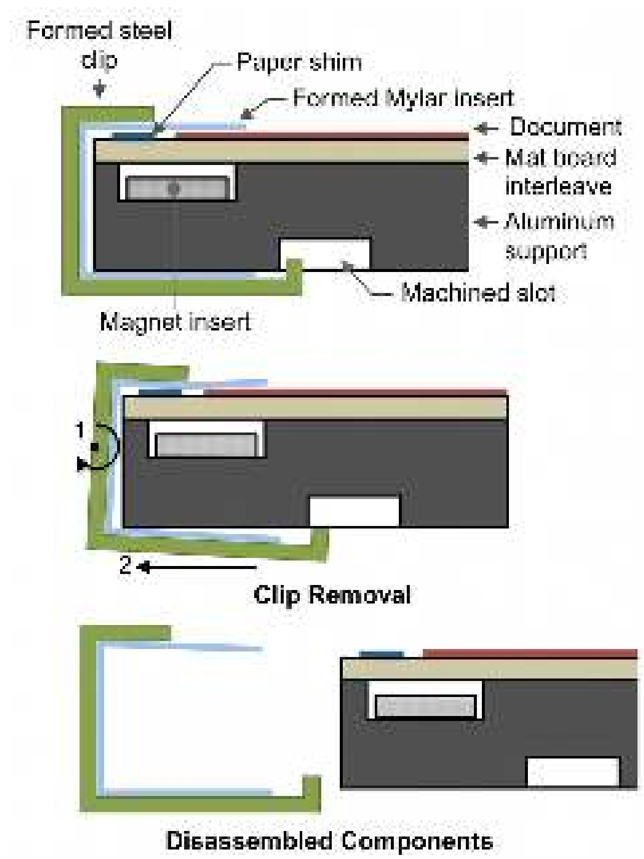

Fig. 7. Cross-section illustration of the clip design used to secure the documents to the support plates.

motion of the clips (slightly visible in Fig. 5c). Finally, lock washers were added to the fasteners beneath the plates to prevent loosening in the event of prolonged vibration.

LEAKAGE TESTS

Prior to installing the documents in the new cases, air leakage tests were performed at CCI using an OxySense optical oxygen analyser. The first experiment was performed with a dry o-ring after flushing the case with nitrogen to remove oxygen. The leakage rate was over 200 parts-per-million per day (ppm/d), which is relatively high for maintaining a low oxygen environment. The second test was performed with silicone grease on the o-ring, which lowered the rate to approximately 20ppm/d. The reduced leakage rate is attributed to the fact that the silicone grease fills imperfections between the mating surfaces. Points of weakness include surface roughness on the base of the machined o-ring groove (esp. machining lines), and the splice joint where ends of the o-ring cord are bonded. Based on these results, it was estimated that after a year, the case would stay below 0.75% oxygen if it is flushed to 100 parts per million without using oxygen scavenger packets. With the oxygen scavenger packets, the case would maintain ppm levels of oxygen for an extended period of time. This fulfills the functional design requirements for a typical loan period.

DISPLAY CASE (OUTER CASE)

The display case was designed and manufactured by Zone Display Cases, a company based in Quebec City. Library and Archives Canada stipulated that the enclosure must meet the necessary security requirements, transport easily to venues across the country, and easily accommodate the two new storage cases. It was also used to address many of the lighting concerns.

In addition to providing a method to securely display the documents, the display case included specialised glazing to control illumination, and a device for monitoring light exposure. Many layers of glazing were incorporated in the design to address a variety of functions. A panel of security glass was used to protect the document from forced entry, and an additional layer of VariGuard (Smart Glass) was added to control the duration of light exposure. By default the glass is opaque; however, when the visitor presses a button, an electrical current excites a material between the layers of glass and it becomes transparent. After a predefined amount of time, the glass reverts back to its opaque state. The signal from the button was also used to activate a set of LED strips to illuminate the document from between the two cases. Finally, a top layer of glazing, which is easily replaceable, served to protect the more valuable glass underneath from scratches.

The display case also features a digital counter to track the cumulative light exposure as visitors to the museum pushed the button. A timer hidden inside the case controls the length of time that the document is visible each time the button is activated. An elapsed time indicator adds the exposure time and allows LAC to monitor the total light exposure while on display through a dose calculation from the known lux level.

CHALLENGES

This project came with many challenges. The idea to build custom cases for these two documents had been discussed several times over the past 30 years. Reading through the large volume of previous research already accumulated on the topic was very time consuming. The timelines for a project that required consultation with many stakeholders was very tight. Testing and design work often had to occur in parallel and designs needed to be adjusted along the way.

Many hours went into determining which materials would be best suited for the project. For example, the first supplier that was approached for the glazing could only provide glass in large uncut sheets. This was not feasible due to budget constraints, so it was necessary to find a different supplier who could cut the glass to our requested dimensions.

Safely mounting the documents to the inner support plate proved far more complex than initially expected. Each document surface was wavy; therefore, it was decided to secure the clips only at the 'valleys' (lowest points) around the perimeter. This required careful measuring and mapping for accurate placement of each clip. The plates were then machined with recesses for the magnets, and slots for the clip restraint using this information.

Finally, it was a significant challenge accomplishing the design specifications while also minimising the associated cost.

PERMANENT INK GUIDELINES

A separate but critical issue that arose from the microfade testing of the signature inks was the need to establish national guidelines or standards for "permanent" inks to be used in signing nationally significant documents. The results of lightfastness tests confirmed that products advertised as pigmented inks have lightfastness ratings significantly higher than conventional formulations that use synthetic dyes.

It was initially thought that standards for writing inks might be used as a guide for ink selection since manufacturers occasionally reference them. Unfortunately, the existing ISO standards are too vague with respect to lightfastness requirements; for example, "The line shall remain visible when tested as specified". (ISO 14145-2, Roller ball pens and refills—Part 2: Documentary use). For archival preservation, an acceptable dose of light exposure to just noticeable fade must be specified. While the British Standard (BS 3484-2:1994 Record inks—Part 2: Specification for permanent inks) is on the right track, testing must be conducted to identify which inks comply with the standard. (…"The ink shall show resistance to fading not less than the equivalent to that of blue wool number 5, grey scale number 4").

Short of legislation or internal policies that require the use of a standard ink, which would be difficult to enforce given constantly changing ink formulations, the simplest most immediate approach with broad impact is EDUCATION. By developing guidelines on choosing permanent inks, LAC should be able to significantly reduce the risk of inferior ink entering the collections by explaining how to choose quality, lightfast permanent ink, and/or providing an approved list.

A letter recently sent out by the Chief Librarian and Archivist of LAC to various federal government agencies asks for their cooperation in promoting the use of pens with lightfast pigmented ink. Corrections Canada, Statistics Canada, the Canadian Nuclear Safety Commission, and Public Works and Government Services Canada (PWGSC) are just a few of the departments that have responded positively. A list of recommended products advertised as pigmented inks is included at the end of the letter. The list is not intended to be exhaustive, and institutions are encouraged to consult product information to determine the nature of the ink colourant.

In the meantime, additional ink samples are being collected for a second phase of lightfastness tests that will be conducted shortly. Library and Archives Canada intends to share information on lightfast inks of high permanence on the LAC website, and through social media in the near future.

CONCLUSIONS

The storage cases and the display case each represent one part of a two part system. Together, they provide the necessary preservation, display, and security requirements to protect two of Canada's most important documents. Moreover, initial steps towards the establishment of national permanent ink guidelines demonstrate leadership in the archival community and a practical effort to encourage the use of lightfast, reliable products that will prolong the life of national archival holdings. The success of this collaborative project has opened doors to the possibility of creating more custom storage cases for LAC treasures and continued research into permanent ink products with continued collaboration with the Canadian Conservation Institute.

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MATERIAL NOTES

Cases based on the designs and technology discussed in this paper are available in various sizes worldwide from Zone Display Cases:

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