

**EXTENDING THE ALTERNATIVE METHOD: USING XEROGRAPHY
AND NONWOVEN FABRIC TO CREATE ACCESSION
NUMBER LABELS FOR MUSEUM TEXTILES**

by

Beth Knight

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ABSTRACT

In 2007, Thomas Braun proposed a method for creating accession labels for museum artifacts that involves xerographically printing accession numbers onto paper and then adhering them to the object, in lieu of numbering objects by hand with ink, which has been the standard method. His method did not encompass labeling textiles, however. This research extends Braun's concept of creating legible, inert labels with xerography to museum textiles and organic objects. Current methods of labeling museum textiles are labor intensive and not always permanent or legible. Various nonwoven fabrics were tested for their feasibility with xerographic printing. Two successful materials were found, Hollytex[®] 3257 and Hollytex[®] 3335. Xerographically printed labels were created and tested against standard textile labeling techniques. The xerographically printed labels proved fairly durable, with some retaining legibility under extreme conditions. The quality and fusion of toner most affected label durability. This labeling method has potential to aid collections managers and museum registrars in the efficient production of inert and legible labels for museum textiles.

Chapter 1

INTRODUCTION

When an object is accepted into a museum's collection (a process called accessioning), it is assigned a unique number called an accession number that is used to identify the object, track it, and connect it with its documentation. This number must somehow physically attach to the object. If the number is lost, incorrect or illegible, museum staff must redirect effort from other essential tasks to finding the documentation that goes with that specific object. In some cases, an object may be entirely disassociated from its provenance simply because its accession number is illegible or missing, and the result is that its unique story is entirely lost.¹ Creating a durable and legible accession label is therefore a small step in the accession process with considerable ramifications.

Textiles in museum collections have been labeled in almost the same way since at least the 1920s: the accession number is written by hand or typewritten onto a textile twill tape that is sewn or tied to a stable part of the textile.² This method has served its purpose, but it has some disadvantages that can lead to loss of the number and inefficient use of time. To name a few drawbacks: numbering labels by hand is

¹ Collections Trust and Margaret Harrison, *Labelling and Marking Museum Objects Booklet*, (Collections Trust, 2009), accessed February 4, 2014, http://www.collectionslink.org.uk/media/content/form2content/documents/c1/a453/f6/Labelling_and_Marking_booklet.pdf.

² Laurence Vail Coleman, *Manual for Small Museums* (New York: G.P. Putman's Sons, 1927), 185.

time consuming, the number may be illegible from the start, the number may be lost entirely over time depending on the ink used, and some numbers may be incorrect due to human error.

While labeling methods for textiles have primarily remained unchanged, advances have been made for other museum objects. In 2007, Thomas Braun proposed a method of creating accession number labels for objects using laser printing or photocopying – processes that are collectively called xerographic printing. For this method, the accession number is printed onto acid-free paper, which can then be adhered to the object using conservation grade adhesives.³ The advantages of this method over the standard method of hand lettering objects with ink on a barrier layer are that the labels are more legible, they can be mass produced quickly, and the size of the labels can be smaller without sacrificing legibility. Photocopier toner is greatly advantageous over the inks used in the hand lettering method because toner has proven to be lightfast and colorfast.⁴

Braun's method is applicable to a broad range of objects for which hand lettering with ink is the norm, but he does not recommend it for textiles. Instead he suggests the old standard of hand lettering the accession number on cotton twill tape with a permanent marker and then sewing the label onto the textile.⁵ Braun's method of using photocopiers and laser printers to create labels could be extended to textiles,

³ Thomas Braun, "An Alternative Technique for Applying Accession Numbers to Museum Artifacts," *Journal of the American Institute for Conservation* 46:2 (2007): 100, accessed February 4, 2014, doi: 10.1179/019713607806112323.

⁴ David Grattan, "The Stability of Photocopied and Laser-printed Documents and Images: General Guidelines," *Canadian Conservation Institute Technical Bulletin* 22 (2000): 5.

⁵ Braun, "Alternative Technique," 99-100.

though. While printing labels onto paper and sewing them onto textiles is impractical because the paper could tear and render the label illegible or incomplete, there are nonwoven fabrics that are capable of feeding through a xerographic printer. Dr. Vicki Cassman came up with the idea for this method a few years ago and it has been on her research to-do list ever since. She saw me as a good fit with this project because my father works in the photocopying industry and I have completed a few internships where creating labels for textile objects were a large part of my duties.

The Canadian Conservation Institute (CCI) has touched on the idea of laser printing accession labels for textiles in one of their CCI Notes, but they recommend using cotton woven fabric that must be sized with Krylon[®] in order to feed through a laser printer.⁶ The process has many of the benefits proposed by Braun, but the many steps involved with creating the label and the time required for the Krylon[®] to dry make the process time consuming.

The purpose of this research is to find a durable, soft, and inert nonwoven material that can be legibly printed upon and that can withstand the temperatures of the xerographic printing process to enable quick, efficient creation of accession labels for museum textiles. Once suitable nonwoven fabric substrates have been found, samples will be created and tested against labeling methods recommended by collections management literature and methods that I have used in internships.

⁶ Canadian Conservation Institute Textile Lab staff, "Applying Accession Numbers to Textiles – CCI Notes 13/8," Canadian Conservation Institute, last modified 2008, <http://www.cci-icc.gc.ca/publications/notes/13-8-eng.aspx>.

Chapter 2

LITERATURE REVIEW

2.1 Basic Textile Labeling

Methods of labeling museum textiles vary from museum to museum, but all of these methods basically consist of writing or typing the accession number onto a fabric substrate, letting the ink dry if necessary, then sewing or tying the label onto a stable and easily accessible area of the textile. “Substrate” is not a technical term used in the field, but will be used here to refer to the fabric part of an accession label, whether it is twill tape or a nonwoven fabric. Since there is no universal standard for labeling, many different substrates and inks are used. Collections Trust⁷ recommends that labels should have the following characteristics:

- **“Secure** - The chances of accidental removal of the label or mark from the object must be extremely low;
- **Reversible** - It should be possible for a label or mark to be removed intentionally from an object, even after 50-100 years with as little trace as possible;

⁷ Collections Trust and Margaret Harrison, *Labelling and Marking Museum Objects Booklet*.

- **Safe for the object** - Neither the materials applied to the object nor the method by which they are applied should risk significant damage to the object;
- **Discreet but visible** - The recommended methods should not spoil the appearance of the object, nor obscure important detail. However, the number should be visible enough to reduce the need to handle the object;
- **Convenient and safe for staff and volunteers** - Materials should be easily available in small quantities at a reasonable price, and should not pose significant risks to health if used in accordance with the guidelines recommended by a local CoSHH risk assessment.”

These characteristics will be considered when evaluating the effectiveness of the labeling methods that are discussed below (see Table 2).

2.2 The Textile Substrate

The label substrate is typically either a woven twill tape or a synthetic nonwoven fabric. Twill tape is available in standard widths and made of cotton, linen or polyester. It should not contain sizing or adhesives. To make an accession number label with twill tape, the tape is cut with excess length that is turned under and sewn to the textile using minimal stitches and fine, strong thread, or tied around a stable part of the textile.⁸ Labeling with twill tape can be challenging because the surface is difficult

⁸ Rebecca A. Buck and Jean Allman Gilmore, *Museum Registration Methods*, 5th edition, (Washington, D.C.: American Association of Museums, 2010), 245.

to write on: loosely woven tapes are difficult to immobilize while writing and the tips of pens snag tape yarns. One conservator recommends pinning the tape to a block of Ethafoam with bamboo skewers to hold the tape in place while writing.⁹ Extra steps such as this show how unwieldy twill tape can be. In the author's experience, inks often bleed along the tape yarns via capillary action, making the lettering illegible or requiring multiple passes with the pen to make a number dark enough to clearly read. In addition to writing difficulties, some twill tapes are so loosely woven that cut ends fray easily, making them difficult to sew to the textile being labeled and aesthetically unacceptable. Twill tape is relatively inexpensive and can also be used to create housing supports for objects, so it is frequently the first choice for labeling despite its drawbacks and challenges.

Synthetic nonwoven fabrics are another commonly used substrate for labeling that are much more user-friendly than twill tapes. Due to their nonwoven structure, the fabric can be cut into any size without the edges raveling, whereas tapes are limited to standard widths. There are many conservation grade nonwovens available with smooth surfaces that make writing easy. Brands such as Hollytex[®], Reemay[®], and Tyvek[®] are

Kathleen Byrne et al, "Appendix J: Marking," *Museum Handbook Part II Museum Records*, (National Park Service), J:9.

Gina Nicole Delfino, "Recommendations for Applying Accession Numbers to Museum Objects: Part 1," *Interpreter*, Minnesota Historical Society, last updated May 2000, <http://www.mnhs.org/about/publications/techtalk/TechTalkMay2000.pdf>.

⁹ Share Museums East, "Labelling and marking textiles in museum collections," *Youtube* video, posted March 30, 2012, <http://www.youtube.com/watch?v=-zCXNphTv0U>.

inert and available through conservation material distributors.¹⁰ All three materials come in varying weights/thicknesses, some of which may not be as soft as woven tapes. Stiff or sharp edges may damage fragile textiles, so lighter weight options like Reemay[®] 2250 (4 mil), Reemay[®] 2014 (8 mil), Hollytex[®] 3249 (1.5 mil), Hollytex[®] 3257 (2.9 mil), and Hollytex[®] 3335 (4.7 mil) are best. Tyvek[®] is available in two “soft” weights, Type 14 and Type 16, which are appropriate as label substrates.¹¹ A warning though: some Tyvek[®] products contain an anti-static layer that can cause corrosion of metals, so care should be taken to purchase Tyvek[®] without additional coatings.¹² Pellon[®] produces a variety of nonwoven interfacings and stabilizers that are inexpensive, readily available, and have very smooth surfaces, but they are bonded with synthetic rubber and therefore should never be substituted for conservation grade materials when the material will be stored with the object for the long term.¹³

Fabric substrates obtained from conservation suppliers should not contain sizing or coatings from the manufacturing process, but if there are concerns, many sources recommend laundering the fabric in mild, perfume-free and non-ionic detergents such as Orvus prior to creating labels to remove these potentially harmful

¹⁰ “Tape, Twill, Archival, Unbleached Cotton, 1/4 to 1/2” W, 36 Yards,” Gaylord, Accessed February 4, 2014, http://www.gaylord.com/adblock.asp?abid=8114&search_by=desc&search_for=tape&mpc=WW.

¹¹ “Product Structures,” DuPont[™], accessed May 1, 2014, http://www2.dupont.com/Tyvek/en_US/products/productstructure.html.

¹² Foekje Boerskma et. al. *Unraveling textiles: A handbook for the preservation of textile collections*. Translated from Dutch. (London: Archetype Publications, 2007), 128.

¹³ “Pellon,” Conservation and Art Materials Encyclopedia Online (CAMEO), Museum of Fine Arts Boston, last updated April 27, 2013, <http://cameo.mfa.org/wiki/Pellon>.

Rebecca A. Buck and Jean Allman Gilmore, *Museum Registration Methods*, 244.

additions.¹⁴ Other sources such as the Canadian Conservation Institute recommend sizing flimsy fabrics with sprays – specifically Krylon®.¹⁵ Some Krylon® products contain cellulose nitrate and other brands’ sprays may contain materials that could harm textiles or cause metal closures and surface decorations to tarnish, so it is best to err on the side of caution and use materials that do not require additional sizing.¹⁶

2.3 Marking Methods

The number portion of an accession label is typically handwritten using ink or typewritten. Braun recommends using ink and cotton twill tape for textile accession labels, which is the most commonly recommended method in labeling guides.¹⁷ The suggested ink varies from source to source, however. Braun, the National Park Service, and *Museum Registration Methods* (to name a few) recommend a Pigma Micron® pen by Sakura. In tests performed by the Registrar’s Committee of the

¹⁴ Nadia Kousari. “Labeling Objects: Tips from the Minnestrista Heritage Collection Basic Collections Care Guide.” *Collections Advisor* (11), August 2012. Last updated August 3, 2012. <http://www.indianahistory.org/our-services/local-history-services/connect/collections-advisor-1/all-issues-by-date/2012.08%20Labeling%20Objects.pdf>

Dorothy H. Dudley et al, *Museum Registration Methods*, 3rd edition, (Washington, D.C.: American Association of Museums, 1979), 51.

Harold Mailand and Dorothy Stites Alig, *Preserving Textiles: A Guide for the Nonspecialist*, (Indianapolis: Indianapolis Museum of Art, 1999), 18.

¹⁵ CCI Textile Lab staff, “Applying Accession Numbers,” revised 2008.

¹⁶ “Krylon,” Conservation and Art Materials Encyclopedia Online (CAMEO), Museum of Fine Arts Boston, last updated January 21, 2014, http://cameo.mfa.org/wiki/Krylon_spray.

Buck and Gilmore, *Museum Registration Methods*, 245.

¹⁷ Braun, “Alternative Technique,” 99-100.

American Association of Museums, the Pigma Micron[®] pen performed best on muslin and cotton tape, marking legibly and showing no noticeable fading after one year.¹⁸ Other pens and inking methods such as the IDenti[®] Pen Dual Point Marker by Sakura and India ink applied with a metal nibbed pen are lightfast, but were illegible and bled on the fabric when tested.¹⁹ The ambiguous term “laundry pen” appears in multiple labeling guides.²⁰ The components and lightfastness of these pens are uncertain, despite the manufacturers’ claims of water and dry cleaning resistance, so they should not be used lest their ink or solvents damage the objects.²¹

Many institutions use Sharpie[®]. Though some sources claim that Sharpie[®] is permanent and safe to use with textiles if the ink has been allowed to thoroughly dry, Sharpie[®] is not archival and has been proven to fade drastically within a month.²² While Sharpie[®] is water resistant, it is soluble in acetone and perchloroethylene, which is the most common dry cleaning solvent. The author has seen a case where one

¹⁸ Buck and Gilmore, *Museum Registration Methods*, 266.

¹⁹ Buck and Gilmore, *Museum Registration Methods*, 266-270.

²⁰ Harold Mailand, *Considerations for the Care of Textiles and Costumes: A Handbook for the non-specialist*, (Indianapolis: Indiana Museum of Art, 1980), 13.

Daniel B. Reibel, *Registration Methods for Small History Museums*, 2nd edition, (Yardley: DBR Publications, 1991), 80.

Jennifer Quérée and Rachael Fone, “Caring for Clothing and Textiles,” *He Rauemi Resource Guide* (24), 2nd ed, (Wellington: National Services Te Paerangi, 2009), 5, accessed February 4, 2014, <http://www.tepapa.govt.nz/SiteCollectionDocuments/NationalServices/Resources/CaringForTextilesAndClothing.pdf>.

²¹ “Sharpie Rub-A-Dub Black 2 Pack,” Sharpie, Accessed February 4, 2014, http://www.theconsumerlink.com/product_detail.asp?BID=Sharpie&T1=TCL+31161PP&navStart=106&.

²² Buck and Gilmore, *Museum Registration Methods*, 270.

missed label on an object led to a dry cleaning disaster when the ink bled on the garment and then became very difficult to remove. Sharpies® should not be used to create permanent labels for museum textiles.

Legibility depends on the individual creating the labels, and therefore can be a potential concern with any pen and ink marking method. Typewriting can help circumnavigate legibility issues, but typewriter ink is not permanent. *Museum Registration Methods* warns that typewriter ink is not very durable unless it is the old correctable carbon ribbon kind.²³ The author has seen labels where the typewritten accession numbers on twill tape have flaked off simply from abrasion of the label with a padded hanger. Typewriter ink components are not well studied, but generally they are composed of a pigment (the highly stable pigment carbon black is present with less stable dyes), a vehicle (various oils are used that may cause yellowing), and proprietary components whose lightfastness and stability are unknown.²⁴ Permanence issues and the potential for harmful degradation products render typewritten labels a less than ideal option, especially as typewriters become an endangered species.

Inkjet printing is more widely available today and can easily combat legibility issues, but its stability is currently under study.²⁵ Inkjet printers that use pigments instead of dyes show promising stability, though their permanence is heavily

²³ Buck and Gilmore, *Museum Registration Methods*, 244.

²⁴ Sarah Norris, "Typewriter Inks: An Annotated Bibliography," last updated December 6, 2006, <http://www.sarahnorris.net/Papers%20&%20Research/Typewriter%20Inks%20Annotated%20Bibliography.pdf>.

²⁵ "Wilhelm Imaging Research," Wilhelm Research Group, accessed May 1, 2014, <http://www.wilhelm-research.com/index.html>.

dependent on the combination of ink and substrate that are used.²⁶ Inkjet ink formulations can vary drastically between manufacturers and are constantly changing, so one combination may not be applicable or available later. With this in mind, many conservators do not recommend using inkjet printers to make labels.²⁷

Xerographic printing has proven to be one of the most permanent printing methods readily available, likely outlasting the substrate onto which the toner is printed because of the stability of toner components, which will be discussed below.²⁸ One of the main advantages of xerographic printing is the increased legibility of accession numbers and the ability to scale down numbers so labels are less obtrusive. Some databases allow can export numbers to printers, which can speed processing and decrease the opportunity for accession number errors.²⁹ There is greater flexibility with font selection, which can affect legibility. According to Braun, good fonts are sans-serif fonts with 1's and 7's that are easily distinguishable, as well as dissimilar number 1's, letter l's, and capital letter I's. Lucinda Console, OCR A Extended (bold), and Tahoma are all good candidates.³⁰ See Table 1 below for examples of good and bad fonts.³¹

²⁶ Hofmann, "Modern Inkjet Prints," 23.

²⁷ Braun, "An Alternative Technique," 97.

²⁸ Sylvia S.Y. Subt and John G. Koloski, *Archival Xerographic Copying: Special Development Study for National Archives and Record Administration*, (Washington, D.C.: Quality Control and Technical Department, August 25, 1987), 8.

²⁹ Braun, "An Alternative Technique," 95.

³⁰ Braun, "An Alternative Technique," 95-96.

³¹ Cassman, Vicki, Course Material, ARTC301: Care and Preservation of Cultural Property I, modified by the author.

Table 1: Font Legibility of 1974.38II (lowercase letter L, capital letter i)

Tahoma	Calibri (Body)	Times New Roman	Garamond
1974.38l 6pt	1974.38l 6pt	1974.38l 6pt	1974.38l 6pt
1974.38l 8pt	1974.38l 8pt	1974.38l 8pt	1974.38l 8pt
1974.38l 10pt	1974.38l 10pt	1974.38l 10pt	1974.38l 10pt
1974.38l 11pt	1974.38l 11pt	1974.38l 11pt	1974.38l 11pt
1974.38l 12pt	1974.38l 12pt	1974.38l 12pt	1974.38l 12pt
1974.38II 12pt	1974.38II 12pt	1974.38II 12pt	1974.38II 12pt

2.4 The Xerographic Printing Process

Xerographic printing is comprised of six basic steps, described succinctly by Grattan³²:

1. Charging: A photoreceptor is given a uniform voltage. The photoreceptor is a drum or belt made of material that conducts electricity when exposed to light.
2. Exposure: The processes for photocopying and laser printing differ in this step. Photocopiers project the desired image onto the photoreceptor to create a latent image. Laser printers use laser beams to “write” the image onto the photoreceptor’s surface, creating the negative image of the photocopied projection.
3. Developing: Dry powder or liquid suspension toner with the same charge as the latent image areas is brought into contact with the photoreceptor, causing the toner to attract to the latent image.

³² Grattan, “Stability,” 2.

4. Transferring: The toner image on the photoreceptor drum or belt is brought into contact with a piece of paper. The charge on the photoreceptor is reversed to release the toner particles.
5. Fusing: Heat and/or pressure are used to fuse dry powder toner to paper. Liquid toners are set after exposure to air.
6. Cleaning: The photoreceptor is brushed to remove remaining toner and exposed to light to erase any remaining xerographic charge.

The two factors that potentially affect xerographically printed nonwoven labels are the temperature of the fusing step and the toner components. Fuser temperatures can range from 130°C to about 210°C.³³ Polyester generally has a melting point of 260°C so it is an ideal candidate for xerographic printing. The fuser temperatures of photocopiers and laser printers can often be set to a lower temperature if a material's melting point is too close to the fuser temperature.³⁴ Lower fuser temperatures are often paired with longer contact of the paper with the photoreceptor, which allows for full fusion of the toner despite the temperature decrease.³⁵ Polyester's glass transition temperature (the temperature range when a material becomes rubbery) is from 68°C to 95°C, which is far below fusing temperatures.³⁶ There is a low risk of melting,

³³ Congrong He et al, "Quantification of the relationship between fuser roller temperature and laser printer emissions," *Journal of Aerosol Science* (41), 2010: 527.

³⁴ Toshiba, *Service Manual: Multifunctional Digital Color Systems e-Studio5540C/6540C/6550C*, (Toshiba Tec Corporation, April 2011): 1459-1479.

³⁵ Charles Knight, conversation with author, December 18, 2013.

³⁶ Sepe, Michael, "PBT & PET Polyester: Part 2 The Performance Factor," *Plastics Technology*, November 2010, accessed on May 26, 2014, <http://www.ptonline.com/columns/pbt-pet-polyester-part-2-the-performance-factor>.

however, because the glass transition temperature of polyester is sufficiently far away from the melting point that the material should maintain its structural integrity without melting in the fusing step.

There are two types of dry powder toners: single and two component toners. Both use carbon black pigment, which is inert, but two component toner uses ferrite as a charging agent to help the attract toner to the paper's surface during the printing process.³⁷ Ferrite could cause staining with time and therefore should be avoided.³⁸ A toner's Material Safety Data Sheet should be consulted to check for ferrite. If a brand name toner contains ferrite, a generic toner may be available that can be substituted to create inert labels using the photocopier or laser printer that a museum already owns.

Single component toner without ferrite has proven to be inert and permanent with one exception: smooth plastics. Grattan warns that toner has a tendency to transfer to PVC plastics as plasticizers migrate into the toner, causing it to soften.³⁹ Some textiles may have plastic components, so xerographically printed labels may not be ideal for these objects if the plastic areas cannot be avoided. In general, though, copiers and printers that use single component toner without ferrite are ideal candidates for printing accession labels for a variety of museum textile objects.

³⁷ Grattan, "Stability," 2.

³⁸ Grattan, "Stability," 3.

³⁹ Grattan, "Stability," 4-5.

2.5 Summary of Labeling Methods

The table below lists commonly used labeling methods, along with their associated advantages and disadvantages. Some of these labeling methods will be tested alongside the laser printed labels in later sections.

Table 2: Labeling Methods

Labeling Method	Advantages	Disadvantages
Ink pen on twill tape	Inexpensive	Difficult to immobilize tape Difficult to sew Inks tend to bleed on tape Must wait for ink to dry Legibility concerns
Typewriter on twill tape	Inexpensive Legible	Difficult to immobilize tape Difficult to sew Numbers can flake off
Ink pen on Tyvek [®]	Inert Edges do not fray	Must wait for ink to dry Legibility concerns
Typewriter on Tyvek [®]	Legible Edges do not fray	Numbers may flake off
Ink pen on Nonwoven	Edges do not fray	Ink may bleed Must wait for ink to dry Legibility concerns
Typewriter on Nonwoven	Legible Edges do not fray	Numbers may flake off
Xerography on Nonwoven	Legible Inert Edges do not fray Most stable writing method	Must research toner to avoid ferrite Cannot use with plastics

Chapter 3

RESEARCH METHODS

Numerous materials were tested for compatibility with xerographic printers. Successful xerographically printed labels were tested against traditional labeling methods. Tests were chosen to replicate the best and worst case scenarios that a label would encounter. Most labels were created with the number 1945.256.380, following the tripartite numbering system and representing all numbers. Labels that were created prior to the start of this research were numbered with 1997.112.3.

Traditional labels were typewritten or hand lettered. The typewritten labels were created using an IBM[®] Wheelwriter[®] 3. Typed labels were created using twill tape, Hollytex[®] 3555, and Hollytex[®] 3257. Hand lettered labels were created using a Sakura Pigma Micron[®] pen on one inch cotton twill tape. Tyvek[®] labels were not tested because Tyvek[®]'s low melting point makes it incompatible with xerographic printing processes.

3.1 Unsuccessful Substrates

A substrate material needs three basic characteristics to be a good candidate for xerographic printing:

1. Melting point higher than fuser temperatures (between 130 – 210 °C)
2. Stiff enough to feed through the xerographic printer, but not so stiff that it could puncture or damage a delicate textile
3. Surface smooth enough for complete toner adhesion

Polyester and rayon are frequently used in conservation, with the added advantage that their melting points can withstand fuser temperatures. A variety of conservation materials (though by no means all) were tested for compatibility with xerographic printing.

It is useful to mention materials that were tested but deemed unsuccessful substrates for xerographic printing. Reemay[®] is a spun bonded polyester nonwoven fabric with a somewhat rough surface that is available in multiple thicknesses. Lighter weight Reemay[®] such as 4 and 8 mil (1 mil = 1/1000 of an inch thick) proved too thin to feed through photocopiers, jamming before reaching the fuser. 12 mil Reemay[®] fed through well, but the surface of the Reemay[®] was not smooth enough for the toner to fully adhere, producing light gray numbers and causing some numbers to be illegible or incomplete. Reemay[®] is therefore not a good choice for xerographic printing, though due to its nonwoven construction, it is a good choice for hand lettering with a Sakura Pigma Micron[®] pen.

Other conservation materials that were examined but deemed too thin to feed through a photocopier included Nomex[®] Soft Wrap and rayon paper. Both these materials are nonwovens that can withstand fuser temperatures and have surfaces that are smooth enough to theoretically print clearly. If their respective manufacturers create a heavier weight product, these materials should be reexamined. Tyvek[®] (spun bonded olefin fibers) may be stiff enough to feed through a xerographic printer and the surface is almost as smooth as paper, but Tyvek[®] shrinks at 132 °C and melts at 135 °C, so it would not withstand fuser temperatures.⁴⁰

⁴⁰ "Product Properties," DuPontTM, accessed May 1, 2014, http://www2.dupont.com/Tyvek/en_US/products/product_properties.html

Though Pellon[®]'s nonwoven materials are not conservation grade because they are bonded with synthetic rubber, they do produce a variety of nonwovens that can feed through a photocopier. The surfaces of Pellon[®] Stitch-n-Tear 806[®] (100% rayon) and Pellon[®] Midweight 50 (100% polyester) are smooth enough to create clear labels and the fabrics fed through photocopiers well. Pellon[®] products may be options for short term labeling needs since their materials are inexpensive and readily available, but they should not in contact with museum objects long-term because the synthetic rubber can degrade fabrics and cause metal fittings to corrode.

3.2 Successful Label Preparation

Hollytex[®] is available in a variety of thicknesses. Hollytex[®] 3257 (2.9 mil) and 3335 (4.7 mil) proved to be the best candidates for xerographic printing.⁴¹ The material is 100% polyester and calendared, which produces a smooth, paper-like surface, while the nonwoven construction gives the material a fabric-like drape and tear resistance. Larger sheets of 3335 and 3257 were cut to 8.5 inches by 11 inches. These smaller sheets were then fed through two different photocopiers and two different laser printers. The equipment used was:

- Method A: HP[®] LaserJet CP1025nw color (laser printer)
- Method B: Xerox Workcentre[®] Bookmark 40 (photocopier)
- Method C: Konica Minolta bizhub[®] 350 (photocopier)
- Method D: HP[®] LaserJet 1200 Series (laser printer)

⁴¹ Hollytex 3249 (1.5 mil) was too thin to feed through a xerographic printer without jamming.

The high fuser temperature used to melt the resin portion of the toner is not problematic with paper, but must be considered when creating labels with synthetic nonwovens that have lower melting points. Many copiers can be set to a “Thick” setting, which lowers the temperature at which the machine operates and lengthens the contact time that the substrate (be it paper or nonwoven material) has with the fuser. When the Hollytex[®] did feed through the machine, it printed completely, so all samples were printed at the copier and laser printers’ standard fuser temperature. Samples were printed using the bypass tray on the photocopiers rather than placing the material in the usual letter sized paper tray. The bypass tray provides a more direct path for the material and decreases opportunity for jams. No extra steps are needed for laser printers: the nonwoven can be placed in the usual letter sized paper tray.

The toners that these machines use were not ideal in all cases. The Material Safety Data Sheets (MSDS) for the Konica Minolta photocopier and HP[®] Color LaserJet 1025nw toners list carbon black as the colorant, which is inert.⁴² The Xerox photocopier toner MSDS lists a proprietary metal oxide, presumably as a charging or coloring agent.⁴³ This metal could be iron or another metal that could cause staining, so this toner is not ideal. The HP[®] 1200 series laser printer toner MSDS lists iron

⁴² Konica Minolta, “Toner TN311 Material Safety Data Sheet,” accessed March 27, 2014, <http://konicaminolta.ca/pdf/msds/MFP-0172.pdf>.

Hewlett-Packard, “HP Color LaserJet CE310A-AD Black Print Cartridge,” accessed March 27, 2014, http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/Countries/us/lj_ce310a-ad_us_eng_v03.pdf.

⁴³ Xerox, Replenisher-Black Material Safety Data Sheet, accessed March 27, 2014, <http://www.xerox.com/download/ehs/msds/P-06.en-us.pdf>.

oxide (also known as ferrite).⁴⁴ Grattan has suggested avoiding ferrite since it may cause staining.⁴⁵ Again, this toner is not ideal. The goal of testing was to check the feasibility of creating labels with xerographic printers and to check the durability of the toner on the nonwoven substrates in comparison to other labeling techniques, so the Xerox and HP[®] 1200 machines were used with the understanding that their toners would not create inert labels.

Label printing results are outlined in the Table 3 below. The materials did not feed through every xerographic printer successfully. Six of the eight materials did successfully print, and five were tested against standard labeling techniques.

Table 3: Printing Results

Printing Method	Hollytex [®] 3257	Hollytex [®] 3335
A: HP [®] Color LaserJet	Good. Sample was not included in later testing.	Good.
B: Xerox photocopier	Poor. Jammed before reaching the fuser.	Fair. Some numbers were faint or incompletely printed.
C: Konica Minolta photocopier	Good. Material appeared puckered after fusing.	Good.
D: HP [®] LaserJet 1200 series	Good. Material appeared puckered after fusing.	Poor. Partially fed through before jamming.

⁴⁴ Hewlett-Packard, "HP LaserJet C7115A-X Print Cartridge," accessed March 27, 2014, http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/Countries/us/lj_c7115a-x_us_eng_v14.pdf.

⁴⁵ Grattan, "Stability," 3.

3.3 Testing Methods

Five different tests were performed, with each designed to replicate a range of scenarios that a label would encounter. These tests were: a peel test, an abrasion test, a crocking test, a solvent test, and a washing test. Lightfastness was not tested because this characteristic has been thoroughly tested and recorded in other sources.⁴⁶ The AATCC Gray Scale for Evaluating Staining and AATCC Gray Scale for Evaluating Change in Color were used to evaluate the results of testing. The scale that was used is specified with each test. The AATCC Gray Scale for Evaluating Staining ranges from 1 to 5, with 1 showing the darkest staining and 5 showing no staining.⁴⁷ The AATCC Gray Scale for Evaluating Change in Color also ranges from 1 to 5, with 1 showing the most color change and 5 showing no color change.⁴⁸

When the labels needed to be sewn to an object surrogate, such as in the solvent and washing tests, the labels were sewn using two to three running stitches with the thread knots secured on the label surface, not on the object surrogate. The nonwoven fabric of the Hollytex[®] does not allow for holes to easily expand, so the label stayed securely attached without the small knots slipping through the holes created by the needle.

3.3.1 Peel Test

A peel test is used to check the adhesion of toner to paper when making archival copies. While toner should not be expected to adhere to a nonwoven fabric in

⁴⁶ Buck and Gilmore, *Museum Registration Methods*, 270.

⁴⁷ AATCC, “Staining,” 2013.

⁴⁸ AATCC, “Color Change,” 2013.

the same way that it fuses to a piece of paper because of the differences in surface topography between the two substrates, a peel test can be used as a preliminary gauge of how effectively toner fuses to a nonwoven fabric. A modified version of the National Archives Peel Test was used to evaluate the adhesion of toner, typewriter ink, and Pigma[®] pen ink on various substrates. The National Archives has a target-shaped print template that is used in the testing. Pieces of 3M #230 drafting tape are placed over the printed target and peeled off at a 180° angle. If the curved edge of the target can be detected on the tape, then the sample fails. The target can be accessed on the National Archives website.⁴⁹

The target template was not used for this test since it could not be reproduced on a typewriter. Instead, accession numbers were printed, typed, or hand written. This modification to the test meant that a smaller area was tested, but small yet important losses such as a period separating two numbers could be more easily detected. Lengths of one inch wide 3M #230 drafting tape long enough to cover the printed number were placed over the number and pressed down with all four fingers. The tape was peeled off at a 180° peel angle as described by the National Archives. The tape was placed on a piece of Mylar and marked with the labeling method that was tested. The tape was examined for traces of toner or ink, noting if the sample passed or failed. The labels were examined for loss of toner or ink and legibility was rated.

⁴⁹ “Testing Electrostatic Copy Quality: The Peel Test,” National Archives, accessed February 4, 2014, <http://www.archives.gov/preservation/technical/peel-test.html>.

3.3.2 Abrasion Test

To test the potential for printed numbers to flake or smear, a Standard Test Method for Abrasion Resistance of Textile Fabrics (D3885-07a) was performed according to the American Society for Testing and Materials (ASTM) International standards.⁵⁰ An SDL Atlas M282 Universal Wear Tester (UWT) was used to test five different xerographically printed samples, one sample of typewriter ink on twill tape, and one sample of Pigma[®] pen on twill tape. Samples were placed in the UWT for five rounds of 100 cycles. After each 100 cycle round, legibility and staining were recorded according to the AATCC Gray Scale for Evaluating Staining.⁵¹

3.3.3 Crocking Test

A modified version of the AATCC Test Method 8, Colorfastness to Crocking was performed.⁵² The University of Delaware Textile Testing Laboratory does not own the apparatus required for this test, so a similar apparatus was created. Normally, a sample is loaded onto a crockmeter which has a cover plate that immobilizes the sample. A metal finger lowers onto the sample, covered with a white standard testing cloth. The crockmeter rubs the metal finger over the sample 10 times. The testing cloth is then removed and the amount of staining is recorded, according to the AATCC

⁵⁰ American Society for Testing and Materials (ASTM). Standard Test Method for Abrasion Resistance of Textile Fabrics (Flexing and Abrasion Method) ASTM D3885-07a(2011). Revised 2011.

⁵¹ American Association of Textile Chemists and Colorists, *Gray Scale for Evaluating Staining (ISO International Standard 105/A02)* (New York: AATCC, 201).

⁵² "Colorfastness to Crocking: AATCC Crockmeter Method," American Association of Textile Chemists and Colorists, last modified 2013, http://www.aatcc.org/technical/test_methods/scopes/tm8.cfm

Gray Scale for Evaluating Staining. The test is performed with dry and wet testing cloths.

Two spring clamps were substituted for the crockmeter, positioned at either end of the label test strip to secure it to a table. White plain weave cotton fabric was cut into squares of approximately 3 inches by 3 inches and secured with a rubber band to the bottom of a 30 mL glass beaker, which acted as the crockmeter finger. The beaker and fabric were passed over the clamped sample 10 times, taking care to keep firm and even pressure. The tests were repeated with dry and wet test cloths for each sample and staining was rated according to the AATCC Staining Scale.

3.3.4 Solvent Test

In some cases dry cleaning is deemed an appropriate treatment for museum textiles. Accession labels should always be removed before any solvent treatment is performed. Human error does occur though, so labels were tested for their dry cleaning stability. Five xerographically printed labels, one label that was typewritten on twill tape, and one handwritten label with Pigma[®] pen on twill tape were all sewn to a cotton/polyester blend blanket and dry cleaned at a local cleaner that uses perchloroethylene, which is a standard dry cleaning solvent. Legibility and loss of ink were evaluated and recorded according to the AATCC Gray Scale for Evaluating Change in Color.⁵³

⁵³ American Association of Textile Chemists and Colorists, *Gray Scale for Evaluating Change in Color (ISO International Standard 105/A02)* (New York: AATCC, 2013).

3.3.5 Wash Test

While museum textiles are never put in a commercial washing machine, the process simulates the worst case scenario for a label and textile: high heat, detergent, and abrasion. This test evaluated the Hollytex[®] labels' overall durability and to see if the hand of the Hollytex[®] changed after washing. Five different xerographically printed labels were sewn to a white cotton washcloth with white all purpose polyester thread using a single running stitch at one end of the labels. A "Normal Warm" load was run for 27 minutes using Tide Pods detergent and Downy Ultra softener. The cloth and labels were allowed to air dry after washing. Any changes in the hand of the Hollytex[®] were noted and legibility of the labels was evaluated. Loss of toner was rated using the AATCC Gray Scale for Evaluating Change in Color.

Chapter 4

DISCUSSION OF FINDINGS

The results of each test can be found in the tables below. Labels were considered illegible when one or more numbers were lost or rendered unreadable. To reiterate, the xerographic printers used were:

- Method A: HP[®] LaserJet CP1025nw color (laser printer)
- Method B: Xerox Workcentre[®] Bookmark 40 (photocopier)
- Method C: Konica Minolta bizhub[®] 350 (photocopier)
- Method D: HP[®] LaserJet 1200 Series (laser printer)

It should be noted that this method is not well suited for printing one or a few individual labels. Full size sheets (8.5 inches x 11 inches) must be used to prevent jamming. Smaller sheets may potentially feed through using an “envelope” or preset label option, but these smaller sizes were not tested.

4.1.1 Peel Test

The xerographically printed labels all remained legible after the peel test tape was removed, showing that the various toners had adhered well to the Hollytex[®] surfaces, even though the toner adhesion failed by the National Archives’s standards. Pigma Micron[®] pen remained equally legible despite failing the test. Typewriter ink failed across all the materials tested, which substantiates sources that caution about typewriter ink’s poor adhesion. The results of the peel test are outlined in Table 4 below.

Table 4: Peel Test Results

Labeling Method	Peel Test Pass/Fail	Remaining Legibility
Hollytex [®] 3335 A	Pass	Good
Hollytex [®] 3335 B	Pass	Good
Hollytex [®] 3335 C	Fail	Good
Hollytex [®] 3257 C	Pass	Good
Hollytex [®] 3257 D	Fail	Fair
Twill with Pigma [®] Pen	Fail	Good
Twill with Typewriter	Fail	Poor
Hollytex [®] 3335 Typewriter	Fail	Poor
Hollytex [®] 3257 Typewriter	Fail	Fair

4.1.2 Abrasion Test

The Hollytex[®] 3335 A was the only label that remained legible after 500 cycles of abrasion (see Table 5 below). The toner on this sample fused flush with the surface of the Hollytex[®], so it may have fused better than the other samples whose toner stood proud of the Hollytex[®] surface. Again, typewriter ink failed quickly and catastrophically. Interestingly, typewriter ink on Hollytex[®] 3335 was the only sample where staining decreased with the number of cycles, resulting in the complete removal of the typewriter ink, which supports claims in the literature about typewriter ink's potential to flake. In general, all other samples were abraded into black smears on the substrate.

Table 5: Abrasion Test Results with Staining Scale

Labeling Method	5	4 - 5	4	3 - 4	3	2 - 3	2	1 - 2	1	Remaining Legibility
Hollytex® 3335 A		100 cycles			200-500 cycles					Legible after 500
Hollytex® 3335 B								100 cycles	200-500 cycles	Illegible after 300
Hollytex® 3335 C	100-200 cycles								300-500 cycles	Illegible after 200
Hollytex® 3257 C	100 cycles				200 cycles				300-500 cycles	Illegible after 200
Hollytex® 3257 D									100-500 cycles	Illegible after 100
Twill with Pigma® Pen			100 cycles		200-300 cycles		400 cycles		500 cycles	Illegible after 200
Twill with Typewriter		100 cycles	200-500 cycles							Illegible after 200
Hollytex® 3335 Typewriter				500 cycles	400 cycles		100-300 cycles			Illegible after 100
Hollytex® 3257 Typewriter					100 cycles			200 cycles	300-500 cycles	Illegible after 100

4.1.3 Crocking Test

In all cases, legibility was not affected, even if staining was heavy (see Table 6 below). Again, Hollytex[®] 3335 A performed the best with little to no staining. Pigma[®] pen on twill smeared drastically. It should be noted that the Pigma[®] pen on twill sample was created months prior to testing, so the ink had ample time to dry. The amount of crocking observed with the Pigma[®] pen on twill tape sample was cause for concern considering that it is a common choice for labeling. Generally, wet crocking tests should produce darker staining than dry crocking, but this was not the case. The wet crocking test was repeated and confirmed the first test's results. This anomaly may be a result of the toner resin's hydrophobic characteristics.

Table 6: Crocking Test Results

Labeling Method	Dry Staining	Wet Staining
Hollytex [®] 3335 A	4-5	5
Hollytex [®] 3335 B	2	3-4
Hollytex [®] 3335 C	4-5	4-5
Hollytex [®] 3257 C	3	4-5
Hollytex [®] 3257 D	2	2
Twill with Pigma [®] Pen	1 and smeared on twill tape	1, very heavy smearing on twill tape
Twill with Typewriter	Not tested	Not tested
Hollytex [®] 3335 Typewriter	4-5	4-5
Hollytex [®] 3257 Typewriter	4	4-5

4.1.4 Solvent Test

Perchloroethylene did not appreciably change the hand of any of the materials. The complete loss of numbers in Hollytex[®] 3335 A may have been exacerbated by the loss of stitching on one side of the label, exposing it to additional abrasion. Again, typewriter ink failed. Pigma[®] pen was very stable, showing no perceptible loss of pigment. The laser printed samples were less consistent; the inconsistencies in legibility between the two “C” samples suggest that the solvent did not determine a sample’s legibility (see Table 7 below). Instead, proper fusion of the toner to the substrate may be the greater determining factor in label durability.

Table 7: Solvent Test Results with Color Change Scale

Labeling Method	5	4 - 5	4	3 - 4	3	2 - 3	2	1 - 2	1	Remaining Legibility
Hollytex [®] 3335 A									X	Complete loss of numbers
Hollytex [®] 3335 B									X	Ghosting of numbers, therefore illegible
Hollytex [®] 3335 C					X					Legible
Hollytex [®] 3257 C								X		Partial loss of numbers
Hollytex [®] 3257 D				X						Legible. Some bleeding (4 on the staining scale)
Twill with Pigma [®] Pen	X									Legible
Twill with Typewriter									X	Complete loss of numbers

4.1.5 Wash Test

The hand of the Hollytex[®] materials did not change appreciably after washing. In this worst case scenario test, most became illegible (see Table 8 below). Surprisingly, Hollytex[®] 3335 B remained legible. All of the samples exhibited some color change, but the numbers that did survive the test were still dark enough to read. Therefore, Hollytex[®] allows toner to completely fuse to its surface and has the potential to survive extremes without losing legibility. As with the wet crocking test, this water resistance may be due to the hydrophobic resin of the toner.

Table 8: Wash Test Results

Labeling Method	Color Change Scale	Remaining Legibility
Hollytex [®] 3335 A	3-4	Illegible
Hollytex [®] 3335 B	4-5	Legible, though abraded
Hollytex [®] 3335 C	3	Illegible
Hollytex [®] 3257 C	3	Illegible
Hollytex [®] 3257 D	3-4	Illegible

Chapter 5

CONCLUSION

5.1 A Method with Potential

The xerographically printed labels proved fairly durable, with some retaining legibility under extreme conditions. The quality and fusion of toner most affected label durability. With a well calibrated xerographic printer that uses single component toner, this method shows great potential for quickly and easily creating large batches of accession numbers. For museums that have infrequent collections committee meetings and/or large influxes of objects, this method can speed up a lengthy accessioning step and decrease transcription errors, especially if numbers can be exported from a database.

5.2 Further Steps

There are likely more conservation approved materials that could be successful candidates for xerographic printing, including more weights of Hollytex[®]. Further research is needed to find compatible materials. Different sizes of material should also be tested so that smaller batches of numbers can be printed, which could greatly increase the applicability of this method by reducing the waste of an entire sheet of material when a single label is needed.

5.3 Additional Applications

Though not mentioned earlier in this research, xerographically printed labels could also function as hang tags. Currently, hang tags are typically a piece of cardstock on which a textile's accession number, location, and other relevant information such as donor and approximate date are hand written for quick reference. This information could easily be printed on Hollytex[®] along with the textile's accession number to speed up the labeling process and remove another opportunity for illegibility. In addition, nonwoven hang tags provide strength without the stiffness of cardstock, which makes the material a good choice for use with fragile artifacts besides textiles, such as archaeological objects. For materials that print well, barcodes could potentially be printed directly on the hang tag. One collection manager mentioned her preference for paper hang tags because she can easily change a location that is written in pencil.⁵⁴ Writing in pencil was facile and marked clearly on the Hollytex[®] materials. Unchanging data such as accession numbers and donor information could be printed onto the nonwoven, with space left for locations to be written by hand. With new technology aiding collections management, this labeling method has the potential for broad applicability.

⁵⁴ Dr. Dilia Lopez-Gydosh, conversation with author, February 17, 2014.

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