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Recording Electronic Images on Roll Microfilm

A Best Practices White Paper

Table of Contents

SCANNING – CHOOSING THE CORRECT RESOLUTION 1

SCANNING – OPTIMIZING AND MAINTAINING IMAGE OUTPUT 2

RECORDING – RASTER IMAGE RECORDERS 2

RECORDING – FUNDAMENTALS AND STRATEGIES 2

MICROFILM – MEDIA 7

MICROFILM – PROCESSING 7

RESIDUAL THIOSULFATE TESTING 8

POLYSULFIDE TONING 9

MICROFILM – QUALITY CONTROL 10

MICROFILM – STORAGE AND INSPECTION 10

CONCLUSION 11

Introduction

The roots of microfilm were planted in 1893 when an English optician named John Dancer and a French chemist named Rene Dagron combined their talents to develop the concept and components of microphotography.[1] Though much has changed since those early days, the simplicity of the technology and the stability and durability of silver halide emulsion have allowed standards and best practices to develop that have withstood the test of time.

As electronic imaging technology has replaced microfilm systems, new methods of recording images on microfilm have emerged. Raster image recorders that can reproduce digitized images on silver halide film have fundamentally changed the way in which preservation microfilm is created. Rather than using reflected light from a physical object to produce a picture, this technology reads the binary data from a digitized image and records the location of each pixel on the film using a CRT (Cathode Ray Tube), LEDs (Light Emitting Diodes) or an electron beam.

Because this process eliminates a conventional camera, the standard for measuring image quality on microfilm [ANSI/AIIM MS51-1991 (ISO 3334:2006) and its corresponding ISO Test Chart #2] no longer applies. **Currently there is no single standard that completely describes the best practice for recording scanned images on microfilm.** The goal of this document is to combine experience with existing standards to allow users of raster image recorders to produce microfilm capable of efficient and effective records preservation, and recovery.

NOTE: As used in this document, the terms scanned images, raster images, digitized images, and binary images all have the same meaning – they are black and white pictures of source media produced by a scanning system or converted from a mark up language such as XML, XHTML or PDF.

Availability of Standards Citations

The standards cited in this document are available from the American National Standards Institute (www.ansi.org) and/or the International Organization for Standardization (www.iso.org).

Scanning – Choosing the Correct Resolution

Resolution is "the degree of sharpness of a computer-generated image as measured by the number of dots per linear inch on a hard-copy printout or the number of pixels across and down on a display screen."[2] The two factors that influence resolution are pixel size and spacing. The smaller the size and the closer the spacing, the greater the resolving power. This is why scanning at 300 dots per inch (abbreviated "dpi") reproduces finer detail than scanning at 200 dpi. Consequently, higher resolutions produce larger file sizes and therefore require more storage space.

The choice of scanning resolution depends on the intended purpose of the digitized image. Smaller characters, thinner lines and fine font details require higher resolutions to faithfully reproduce them. If basic legibility is the goal, a resolution of 200 dpi will sufficiently render the

[1] http://www.srlf.ucla.edu/exhibit/text/default.htm – The History Of Microfilm: 1893 To The Present Exhibition Documentation

[2] http://dictionary.reference.com/browse/resolution

10 to 12 point typefaces that are typically in recorded real estate documents. When type sizes are in the 6 to 9 point range or the scanned images are to be subjected to Optical Character Recognition[3], 300 dpi resolution is preferred because it produces sharper lines. Smaller fonts or fonts that contain detailed serifs require resolution in the 400 to 600 dpi range depending on the characteristics in the font that are to be preserved.

Scanning – Optimizing and Maintaining Image Output

Because scanned real estate documents are black and white and are typically output in a binary format, some people have assumed that image quality and consistency tests are not important or perhaps even necessary. This is not true. All optical and mechanical systems (in this case scanners and raster image recorders) are affected by temperature, humidity and general wear and tear. Routine maintenance and calibration are necessary to keep these systems operating at their expected performance level. The only way to know that attention is needed is to test the systems for variances from their norm.

In an electronic imaging application, a scanner replaces the camera as the capture device. If it is not able to produce an image of sufficient quality, all downstream processes and applications suffer. By using the quality assessment tools and procedures described in the AIIM/ANSI standard MS44-1993, a scanner's quality level and consistency can be measured, recorded and retained for future reference. Without this information, subtle changes in image quality accumulate over time resulting in a degradation of document legibility that often goes unnoticed until the problem becomes significant. Quality control processes are very important. By comparing periodic MS44 test results to those achieved when the scanner has been optimized for quality output, problems can be discovered and resolved before important information is degraded or lost.

Recording – Raster Image Recorders

The first image recorders were Computer Output Microfilm (COM)[4] devices. They were developed to "archive" computer readable text such as index databases on to microfilm for long term backup and preservation. As electronic imaging matured in the 1990s, the need to apply this type of process to digitized documents became obvious. Early manufacturers of image to film recorders included such firms as Image Graphics, Anacomp, and Eastman Kodak, followed more recently by several others.

In a relatively short period of time, raster image recorders have become a common peripheral attached to a document recording system. As is often the case, purchasing the hardware is the easiest part of the process. Making it function completely, consistently, and correctly is where the real work lies.

Recording – Fundamentals and Strategies

Presenting a quality image to a microfilm recording system is just one of several factors involved in producing preservation quality microfilm. Like scanners, these systems need attention and an

[3] Optical Character Recognition (OCR) is a process that uses shape recognition software to convert digitized characters to computer readable text such as ASCII or EBCDIC.

[4] http://www.archives.nysed.gov/altformats/ServicesGovRecs/ns_serv_mg_pub52.pdf

understanding of their abilities to produce microfilm that is not only suitable for preservation, but for efficient recovery as well. The items listed below address many of the key issues that make these systems work as expected.

- Maintenance – A good image can become illegible if maintenance is not performed on the image recording system. Mechanical and optical sub-systems need to be routinely inspected and maintained if they are to produce optimum image quality. The maintenance cycle is usually linked to the volume of film produced. Consult the equipment manufacture about an appropriate maintenance schedule.

  Preventative maintenance is obviously preferred over repairing a damaged system. Subtle changes in background density over time may indicate that the optical system needs cleaning. Evidence of character compression or stretching on the film is an indication of a developing mechanical problem in the image writer. When looking for character quality variances, a minimum of 15X magnification should be used to view four or five sections in each roll.

- Valid Image Formats – Microfilm recorders can be selective as to the type of image file they will accept. Some systems can process binary, grayscale and color images while others will only accept binary images in a specific Tagged Image File Format (TIFF) using ITU G4 compression. Before submitting image files for recording, be sure that they are compatible with the recording system you intend to use.

- Organization – Microfilm may be the last medium available to recover lost files. If it is to be effective, the recovery process should be as efficient and inexpensive as possible. Pre-recording checks to assure that every document file is complete and presented to the recording system in sequential, ascending order is critical to producing a microfilm collection that can be effectively and efficiently recovered.

- Page Size Versus Film Size – Documents that include letter/A size (8.5"X11"), legal (8.5"X14") and tabloid/B size (11"X17") pages are suitable for recording on 16mm film. Larger formats such as C size (17"X22"), D size (34"X22") or, E size (35"X44") are best preserved on 35mm film.

- Film Polarity – Microfilm used in conventional cameras produces "negative appearing" images (clear characters on a black background) from "positive appearing" source pages (black characters on a white background). For this reason, this first generation camera film has been called the "camera negative".

  Raster image recorders are capable of accepting positive or negative appearing digitized images and producing positive or negative appearing images on microfilm. Unless there is a compelling reason to produce positive appearing microfilm, negative is preferred. Negative film more effectively hides dust and other foreign material that can become attached to the film and it does a better job of hiding base side film scratches. Because of this, pages scanned from negative film produce cleaner looking images with smaller file sizes.

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- Image Contrast – Sufficient contrast between character and background density is important to producing film that will print or scan clearly. The exposure level in the image writer's software should be set to produce a 0.85 – 0.95 background density for 200 dpi scanning and a 0.95 – 1.05 background density for 300 dpi scanning. Background density is measured in the dark areas of the image using a properly calibrated transmission densitometer.

  Because letters and numbers reproduced on a microfilm are usually very small, character density can only be accurately measured by a micro-densitometer. Ideally, character density should be below .2 on the density scale. Microfilm scanners produce clearer text from characters that are as clear as possible on film without lowering the background density below the recommended levels. Line thickness varies with the type face and font size and this can affect the density of characters on the film. When choosing a reduction ratio and exposure level, the appearance of the characters on the source page should be taken into consideration.

- Blip Coding – Critical to an effectively organized microfilm file is the use of a multi-level blip coding strategy. Blips are rectangular marks exposed by the film recorder under each page as they are written on the film. These marks can be programmed to appear in up to three sizes to identify file level, document level, and page level images. Applying this sequence to recorded documents, a large blip would indicate the beginning of a book, a mid-sized blip would then indicate the first page of a document within the book, and a small blip would indicate a supporting page within that document. If a document number rather than book and page system is used, a two-level blipping scheme is sufficient. A large blip designates the first page of a document while small blips indicate supporting pages within the document.

  Microfilm scanners with the ability to sense these variations in blip size are able to export this information to a program that can automatically staple pages together into documents. If the documents are recorded on the film in sequential order, the instrument number can also be automatically assigned to each document using the document level blip as the sequence indicator.

- Page Orientation – Pages can be recorded on microfilm in two ways. In "cine mode" where the text on a page runs perpendicular to the length of the film and in "comic mode" where the text on a page runs parallel to the length of the film. A page scanned "head first" will be written on the film in cine mode with the top of the page point toward the beginning of the film. Unless a lower reduction ratio is needed for acceptable image quality, recording letter and legal sized pages in comic mode is preferable. This is accomplished by rotating the images 90º prior to recording or feeding the page "sideways" through the scanner.

  The advantage of comic mode recording is that more pages can be written on each roll of film saving storage space and promoting more efficient scanning in the event that the film needs to be used to recover lost image data.

- Skew – Skew is defined as having an oblique direction or position; slanting.[5] Images that are tilted to the left or right of perpendicular are said to be "skewed". Prior to recording on the film, digitized images should be de-skewed to permit maximum packing density on the film and to produce an easily read page when rescanned and displayed on a monitor.

- Reduction Ratio – The reduction ratio is the number of times a source page is reduced in size when recorded on film. For example an 8.5"X14" page reduced 29 times becomes 0.293" (7.44mm) wide and 0.483" (12.26mm) high. This is considered to be a 29X reduction ratio and will comfortably fit legal and letter size pages on 16mm film in comic mode leaving sufficient room under each page for a blip mark.

- Page Spacing – Pages need to have sufficient separation to allow a film scanner to reliably differentiate adjacent pages on the film. There should be a minimum separation of 0.06" (1.5mm) between adjacent pages. Pages that touch each other at any point may preclude them from being captured separately by a microfilm scanner. If splicing must occur within a film roll, additional space between frames will be required to accommodate the splicing process.

- Packing Density – Microfilm is manufactured in 100 and 215 foot lengths. The film's thickness determines its length. The thickness of a 100 foot roll of film is 5 mils (.005 inches or 0.127mm) while the thickness of the 215 foot film is 2.5 mils (.0025 inches or 0.064mm). Because of this thickness change, film of either length fits comfortably on a standard "100 foot" reel.

  The conversion from acetate to polyester base film in the mid 1970s made it possible to reduce the thickness and still have a very durable and dimensionally stable product. All 5 mil and 2.5 mil films are now manufactured with a polyester base (a.k.a. "Estar").

  Based on a page separation of 0.06" (1.5mm) and comic mode recording on 16mm film, the chart below shows an estimated maximum number of images that can be recorded on each length of film.

Page Size	Reduction Ratio	Images/100' Roll[1]	Images/200' Roll[2]
8.5" X 11"	24X	2,400	5,600
8.5" X 14"	29X	2,800	6,600
11" X 17"	36X	2,700	6,400

1. Depending on hardware and software, a 100' roll of film yields approximately 84 feet of useable film.
2. Depending on hardware and software, a 200' roll of film yields approximately 195 feet of useable film.

These packing densities many vary somewhat depending on equipment manufacturer, model number, or software version being used.

IMPORTANT NOTE: Although maximizing packing density improves scanning efficiency, documents recorded on film should not span rolls.

[5] http://dictionary.reference.com/browse/skew

- Targets – Targets are informational pages on a roll of film. They typically identify the beginning, end, and content of the document collection. Examples of targets are:

  - *Start* – A "START" target notifies the viewer that relevant information follows.

  - *Quality Control* – This is a target that reveals the combined quality of the image capture sub-systems. In traditional microfilming, an ANSI 1010a resolution target is used. This target reveals performance information about both the camera and the film processing systems.

    Film produced by raster image recorders cannot use this target because of technical issues such as aliasing.[6] Because scanning systems are not dependent on raster image recorders to display their images, a single target has not been developed to record the performance of both. Current choices are limited to the IEEE Std. 167A.1-1995 test target that is called out in ANSI/AIIM MS44 and any quality control target(s) that accompany the purchase of a raster image recorder.

    The IEEE Std. 167A.1-1995 test target should be digitized at regular intervals during production scanning to check the output consistency of the image capture system. When images are recorded on film, those digitized targets that bracketed the scanned images should be recorded on the roll bracketing the filmed images. The intent is to document the scanner's performance before the batch was started and after it ended. If the results on both targets show that the minimum level of acceptable quality was met, there is a high probability that the images scanned between those targets also met the minimum level quality.

    If the manufacturer of the image recorder provides an electronic test target, it should also be recorded before and after the set of pages being recorded. The intent is to document the acceptable performance of the recording system.

  - *Certification* – A certification target is intended to assure the viewer that the images on the film are faithful and accurate reproductions of the original documents. Typically these targets contain a sworn statement that is signed by an authoritative party and should appear at the beginning and end of the roll.

  - *Unused Document Number* – To maintain order, completeness, and the ability to auto-index a multi-level blipped roll of film, every document number (or page number in a book/page system) must be accounted for on the film. When a number has been skipped, a target for each missing number should be recorded in the location where the document would have appeared on the film. This scanned target should contain the missing number and acknowledge the reason it was unused.

[6] http://dictionary.reference.com/search?r=2&q=aliasing – Aliasing: The appearance of jagged distortions in curves and diagonal lines in computer graphics because the resolution is limited or diminished.

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- Splicing – Adding pages to or subtracting pages from a processed film roll has been a common and accepted microfilming practice. This is primarily due to the fact that the completeness and correctness of the images on a roll could only be determined after filming and processing were completed. Rather than re-film all of the pages on a roll to correct a few mistakes, splicing in strips of corrected images was seen as the most convenient and economical way to solve the problem.

  Splicers for acetate film used mylar tape or heat to bond the film together. Polyester base microfilm introduced in the mid 1970s requires an ultrasonic splicer for this process. Although ultrasonic splices meet preservation standards, the film is overlapped in the bonding process. This overlap creates a "bump" when it encounters a drive roller on a film scanner. This bump produces a vibration that travels along the film and can affect the legibility of a page that is in the scan aperture.

  To insure the veracity of the images in spliced film, the reason for each splice is supposed to be documented. In practice this rarely occurs. When records with legal significance are involved, undocumented splices can create questions about the purpose and consequence of the splicing activity.

  The convergence of document scanning and raster image recording has created a unique opportunity to abandon the practice of splicing. When all legibility/completeness checks and edits are done on the electronic image file, any problems found are easily corrected prior to creating film. When this practice is followed, microfilm is not only capable of preserving the documents it holds but it can also add a measure of insurance against document fraud.

  Because of the reasons stated above, it is strongly recommended that the practice of splicing be eliminated in favor of digitized image file editing as the preferred process for correcting mistakes. If splicing cannot be avoided, splicing procedures should follow the recommendations found in ANSI/AIIM MS18-1992 (R1998).

Microfilm – Media

Preservation microfilm must meet the manufacturing requirements stated in ISO 18901:2002. All black and white microfilms manufactured for use in raster image recorders meet this standard.

Microfilm – Processing

Processing is the step where exposed film is passed through a developing machine that contains a series of chemical solutions to reveal and permanently fix the images that were written by the raster image recorder. Proper processing is critical when producing microfilm for preservation purposes. Developer and fixer solutions must be maintained within the concentration range recommended by the chemical manufacturer. This is accomplished by either completely replacing the chemistry as necessary or by the use of a replenishment system where fresh chemistry is added as film is processed. Below is a brief explanation of the steps involved in processing film and why each is important.

- Developing – Developer is the chemical that reveals the latent image[7] that is created by exposing film to light. The expected outcome of properly maintained developer is consistent background density as measured by a densitometer on areas that have been exposed to the same amount of light.

- Fixing – The function of fixing chemistry is to stabilize the developed image by removing silver from the unexposed areas of the film. Fixer not only needs to be refreshed, the silver it accumulates needs to be removed or it will be come saturated and ineffective. This is done through the use of an electrochemical silver recovery device. Spent fixer is considered to be toxic waste and cannot be washed down the drain without being adequately diluted and properly treated for excess silver.

- Washing – Rinsing the film of excess fixer is critical to insuring that the images will meet the minimum longevity expectation of 500 years. If there isn't sufficient circulation and turnover in the wash water tank, processed film may exceed the required residual thiosulfate limit stated in ISO 18901:2002.

- Drying – Inadequate drying can affect the physical integrity of the film's emulsion layer. Film that has not dried sufficiently can stick to itself as it wraps up on processor's the take-up reel. When the film is unrolled, the emulsion layer that holds the image can adhere to the adjacent film wrap and break away possibly affecting the integrity of an image.

To minimize density variation due to latent image fade[8], process film at consistent time intervals after rolls are exposed.

Residual Thiosulfate Testing

For microfilm to achieve a useful Life Expectancy rating of 500 years (designated as LE-500), the amount of residual thiosulfate (fixer) left on the film after drying must fall below the stated level in the film stability standard ISO 18901:2002. If the test value is above this limit, the film must be recreated or re-washed and then re-tested. When the amount of residual fixer tests at an acceptable level, the result should be recorded in a processing log to document compliance.

The standard that describes the test methods for determining the amount of residual thiosulfate that remains on processed film is ISO 18917:1999. For microfilm, the Methylene Blue method is recommended.

A processor that is capable of achieving the recommended level of residual thiosulfate must be properly monitored and maintained to continuously meet the standard. Again, preventative maintenance is preferred. The amount of use compared to the rated duty cycle of the processor will likely determine the maintenance schedule and this should be discussed with the equipment manufacturer. Maintenance typically consists of cleaning guide rollers and tanks, changing water and chemical filters, checking and replacing bearings and refreshing chemistry.

[7] The initial image produced by exposing unprocessed film to light is called a "latent image".
[8] The intensity of a latent image marginally degrades for a short period of time following the exposure. The sooner the film is developed after exposure, the less effect latent image fade has on the processed image.

IMPORTANT NOTE: Film processing and its associated quality control procedures require the use of moderately expensive, hazardous chemicals. As electronic imaging technology has replaced microfilm retrieval, the knowledge necessary to produce preservation quality film has become less common. It is important that the person or company chosen to perform these important tasks has the commitment, skill and knowledge necessary to carry them out in a manner that will meet the requirements for preservation microfilming.

Microfilm manufactures recommend that the following procedures be performed on a daily basis to assure that film is processed correctly:

- Scratch Test – Process light struck film and inspect it closely for fine to obvious scratches that were caused by the processor.

- Process Control Strips – Use a sensitometer to expose a step wedge on specially manufactured film and then process it to determine proper and consistent development.

- Residual Thiosulfate Testing – Use the Methylene Blue testing method to determine that processed film has been sufficiently rinsed of fixer.

- Process Control Charts – Maintain a written record of these test results for future reference and to document the film's processing quality and Life Expectancy rating.

Each month, samples of processed film should be sent to an independent and qualified lab to verify that the in-house process control strip and residual thiosulfate results are within industry standards.

Polysulfide Toning

Polysulfide toning (sometimes called "brown toning") is a chemical treatment that protects microfilm images from the adverse effects of airborne oxidizing agents. It does this by converting a significant percentage of the photosensitive silver halide in the film's emulsion to silver sulfide. This process can be applied to new film during processing or to existing microfilm as a separate process.

This optional treatment provides an additional layer of protection to preservation microfilm. Oxidizing agents come from a variety of sources such as smoke, automobile exhaust, certain types of paint and deteriorating wood products.

Evidence of oxidation appears as small orange spots in the dark areas on the film. Often referred to as "redox" (after the associated chemical reaction called reduction/oxidation) or "measles" because of their appearance as red spots on the film, these affects are not contagious but are a clear indication of improper storage conditions.

The polysulfide treatment process must be performed by an experienced film lab and must follow the procedures stated in ISO 18915:2000.

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Microfilm – Quality Control

When the film images have been produced by independent systems, as is the case with scanners and raster image recorders, quality assurance becomes a dual level process. As stated earlier, a significant advantages of electronic imaging is the ability to view the digitized image files for organization, legibility, skew, contrast, and completeness before recording them on film. By assuring that the file to be filmed is properly organized and complete the need to edit or re-run a roll is substantially reduced.

Once the digitized image file is properly organized and prepared, recording the images on film is a fairly straightforward process that is accomplished within the software provided by equipment manufacturer. The film quality assurance process should include verifying completeness by comparing image writer's output log files to the Grantee/Grantor index files for the corresponding images.

After processing, the film should go through a visual check for legibility, correct blip placement, uniform background density, proper formatting, and sufficient contrast. Suspending the film over a light box using two manual rewinds to roll it back and forth is the best way to check the film for these qualities. The examining technician should wear cotton gloves to minimize the risk of damage to the film. Four or five random sections in each roll should be viewed with a minimum of 15X magnification when looking for character uniformity. If any characters show any degree of stretch or compression, the entire roll should be rejected, as this is an indication of problems with the image recording system.

Microfilm – Storage and Inspection

The last step to achieving an LE-500 longevity rating involves storage practices. Microfilm must be place in acceptable boxes and consistently stored under proper environmental conditions. The standard that applies to enclosures is ISO 18902:2001 and ISO 18911:2000 is the standard that applies to the storage environment. The intent of these standards is to keep film in an appropriate and stable temperature and humidity range and to protect it from harmful chemicals. Airborne oxidants are an example of chemicals that are of particular concern.

- Redox/Measles – Oxidizing agents react with the silver grains in the emulsion that form the dark areas of an image. The result is small orange spots that are often called "redox" or "measles". Initially, these spots are primarily a cosmetic problem but, as the reaction progresses, the legibility of information on the film can be affected. Unless certified as acid free and lignin free, cardboard boxes contain both of these compounds and, over time, they react to produce the very potent oxidant, peroxide. Enclosures should pass the Photographic Activity Test before being used for storing microfilm. ISO 14523:1999 describes the processes and procedures used to determine the level of chemical activity between silver halide emulsion and various types of enclosures.

  Contrary to some rumors, redox spots do not spread on their own. They typically start to appear at the beginning of a roll because contaminated air can freely circulate around loosely wrapped film. As time passes, the air is able to work its way deeper into the film wraps causing the degradation to appear to spread along the its length. Any evidence of redox is a clear indication that the film has been or is being stored improperly. Redox cannot be

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cleaned off or otherwise removed but further damage can be avoided by correcting the storage environment.

- Vinegar Syndrome – Another chemical process that only affects older acetate film is Vinegar Syndrome. The cellulose acetate that is used to make the base material for this film is vulnerable to decomposition from effects of heat, moisture, and acid. Processed and stored correctly, acetate base microfilm has a Life Expectancy rating of 100 years. Improper storage, however, can reduce its LE to just a few decades.[9]

  Initially, atmospheric heat and moisture cause a gradual separation of *acetyl* (CH_3CO) from the cellulose molecules. This causes acetic acid to gradually build up in the film's base. At a certain point, the production of acid becomes very rapid where the reaction rate is driven more by the production of acid than by atmospheric influences.[10] The degradation process begins feeding off of itself causing an autocatalytic reaction that cannot be stopped.

  The first noticeable sign of Vinegar Syndrome is the telltale smell of vinegar when the film box is opened. The solution to avoiding the inevitable and irreversible damage that this process causes is to copy it to silver polyester base film. If this is not done soon enough, the film base will become distorted, then wet with acetic acid and eventually begin sticking to itself. Eventually it will become what is known in the industry as a "hockey puck".

Microfilm should be periodically inspected for physical deterioration as outlined in ISO 12031:2000.

Conclusion

The simplicity and human readability of microfilm substantially differentiates it from its digitized and digital counterparts. When the steps outlined in this document are followed, microfilm requires relatively little attention to achieve its preservation potential. Using today's document scanning and microfilm technology, properly produced, processed, and stored microfilm can be a very reliable and cost effective asset in a multi-layered records preservation program.

[9] James M Reilly, *IPI Storage Guide for Acetate Film* (Image Permanence Institute 1993 revised 1996), p. 10
[10] James M Reilly, *IPI Storage Guide for Acetate Film* (Image Permanence Institute 1993 revised 1996), p. 13

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