Notes on Microfilm

by **KLAUS B. HENDRIKS***

Microfilm rolls and fiches constitute a widely used information storage medium. One of the reasons that attracted archives and libraries to this medium is the savings in space and handling costs resulting from the conversion of original source documents to microfilm. For example, a single roll of microfilm can hold up to 2,500 pages which can then be distributed easily to a large number of users. Microfilm allows for the storage of both textual and machine-readable documents in a human readable form (COM). In addition, the excellent permanence characteristics of processed microfilm records are well established. The purpose of these notes is to review the current knowledge of the factors which affect the longevity of microfilm as an archival medium.

Microfilm in general belongs to the generic group known as silver gelatin photographic records.[1] These records comprise by far the largest number of photographic materials in existence. Applications of this type include black-and-white motion picture films, X-ray films, aerial films and microfilm. The majority of pictures in historical still photographic collections are silver gelatin materials. This generic term indicates that the image-forming substance consists of microscopically small particles of elemental silver held in place by a binder layer of gelatin. Developed in the 1880s, the properties of silver gelatin photographic materials have been studied for over one hundred years, first empirically and later — since the beginning of this century — in the research laboratories of various manufacturers, using increasingly sophisticated equipment developed for that purpose.

One of these properties is the resistance of processed photographic materials to deteriorating factors. The causes of possible deterioration are well known and so are, consequently, the conditions of storage and handling that are conducive to the longevity of films and photographs. The experience of manufacturers and users alike with respect to the properties of silver gelatin microfilm has been accumulated for over six decades. This type of microfilm, the subject of these notes, was introduced by the Eastman Kodak Company in 1929 for the purpose of quickly producing copies of cheques in the banking industry.[2]

The question of how long a given document (paper, film, magnetic tape) may last is meaningful only if the conditions are specified under which it is to last. The permanence of processed microfilm depends upon three factors:

1. The type of material produced by the manufacturer.

2. The processing of the exposed film.

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1 There are also other film types, such as vesicular and diazo film — mostly used for copy purposes — which are not discussed here.

2 C.E. Kenneth Mees, "Amateur Cinematography and the Kodacolor Process," *Journal of the Franklin Institute* 207 (1929), pp. 1-17.

3. The subsequent storage conditions under which the processed film is kept and the amount of damage it may suffer during use.

While the responsibility for the first of these factors lies with the manufacturer, the user of microfilm must ensure that the processing is done correctly and that the processed film is kept under suitable conditions.

Concerning the quality of microfilm produced today, all products by major manufacturers meet two specifications set out by the American National Standards Institute (ANSI). One of these specifications deals with films on a cellulose ester support, ANSI PH1.28, the other with films on a polyester base (known to chemists as polyethylene terephthalate; brand names: Cronar, Terephane, Melinex, Mylar, Estar), ANSI PH1.41.[3] Such specifications result from experiences of manufacturers and users with earlier film materials that are notorious for their instability: cellulose nitrate, which is inherently unstable and highly flammable, and cellulose diacetate or mixed ester films which are known to shrink, creating a creased image layer.[4]

ANSI standards PH1.28-1984 and PH1.41-1984 are significant. In the mid-1970s, the chairman of the ANSI Task Group PH1-3 (Dr. P.Z. Adelstein, Eastman Kodak Company), in search of a definition for the terms archival and permanent, wrote to the Archivist of the United States for clarification. The response by Dr. James B. Rhoads, which was published in three technical journals, is reprinted here in part:

> Archival and Permanent:
>
> Essentially these terms are synonymous and are frequently used interchangeably. To us they have the same meaning: that is, forever. To say that we are going to keep forever everything that is now classified as archival or permanent is a rather positive statement and one which none of us can guarantee. Yet it does express our intention in relation to records which have been appraised as being of permanent value, or archival.
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> This clarification is also important because it is necessary that whatever material is approved for permanent record filming must be equal to or better than the present materials that have been certified for permanent record use. For this reason the standards that this or similar groups develop must be stringent so that only those of the highest quality will ultimately be approved.
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> Permanent or archival record film can be defined as any film that is equal to or better than silver film as specified in ANSI specifications PH1.28 and PH1.41. We realize that equating other film types to silver may not be the best criteria, but at this time it is the only standard that we have. Silver has been around long enough to lend some credence to its stability as an archival material, yet if newer materials can be qualified they too should be considered for certification.

3 American National Standards Institute, *American National Standard for Photography (Film) — Archival Records, Silver-Gelatin Type, on Cellulose Ester Base.* ANSI/ASC PH1.28-1984 (New York, 1984). American National Standards Institute, *American National Standard for Photography (Film) — Archival Records, Silver-Gelatin Type, on Polyester Base.* ANSI/ASC PH1.41-1984 (New York, 1984).

4 Microfilm generally was not produced on a cellulose nitrate film base.

> The bulk of information being filmed today is not of an archival nature and should not be retained permanently. It should be retained for periods between 10 and 100 years. Thus, standards for these periods are of importance so as to ensure the keeping quality of the media and the record content for these periods.[5]

This definition of permanent or archival record film was subsequently endorsed by the then Dominion Archivist, Dr. W.I. Smith.

The use of microfilm places an additional burden on archivists and librarians that does not exist for paper and magnetically recorded media: the chemical processing of microfilm. During processing, exposed silver halide compounds are converted to elemental silver in the development step. In the following fixing step, unexposed silver halide is removed. It then becomes necessary to wash out all residual fixing compounds in a washing step, which is followed by the final drying period.

If a film is underfixed, residual silver halides could remain in the gelatin layer which will lead to discoloration. If a film is poorly washed, residual fixing salts may remain in the emulsion layer which could also cause discoloration of the picture, usually yellowing and fading. The maximum permissible amount of fixing salts (chemical term: sodium or ammonium thiosulfate) is specified in the previously mentioned ANSI standards.[6] Analytical methods for measuring residual amounts of thiosulfate are also described in another standard published by ANSI.[7] The tests that can be used are the Methylene Blue Method, the Silver Densitometric Method, and the Iodometric Method. Therefore, the quality of processing can be perfectly controlled if the processing laboratory is willing and able to implement tests that will ensure the correct processing, and to record the result of these tests accurately.[8] Table 1 provides a list of essential data that should be recorded for microfilm that contains information having permanent value.

The third principal factor determining the longevity of processed microfilm is the conditions under which it is kept. Overriding influence is exerted by a combination of high relative humidity (RH) in the presence of aggressive, *i.e.* oxidizing chemicals. Examples are residual processing chemicals left in the film and high relative humidity, or the presence of chemicals known as peroxides — which may be perceived as reactive forms of oxygen — along with a humid environment. It has been reported by Pope in 1963 that the presence of residual fixing salts in microfilm will not lead to discoloration at

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5 Peter Z. Adelstein and James B. Rhoads, "Dialogue on Standards: Archival Permanence," *Journal of Micrographics* 9, no. 4 (1976), pp. 193-94. Also published in *Journal of Applied Photographic Engineering* 2, no. 2 (1976), p. 64A and *Microform Review* 5, no. 2 (1976), p. 90.

6 This threshold value is currently 0.7 mg of thiosulfate per cm^2 of (fine-grained) microfilm. An ANSI Task Group studying the effect of residual processing chemicals on the stability of processed photographic films has all but concluded that this value is too tight. Future issues of ANSI PH1.28 and PH1.41 are expected to allow higher values of residual thiosulfate.

7 American National Standards Institute, *American National Standard for Photography (Chemicals) — Residual Thiosulfate and Other Chemicals in Films, Plates, and Papers — Determination and Measurement.* ANSI/ASC PH4.8-1985 (New York, 1985).

8 Measuring daily the amount of residual thiosulfate on dozens of film rolls is not a particularly exciting job. The work requires knowledge of chemistry and laboratory skills which are usually obtained by an academic training to the bachelor's level. The job could be made more attractive by adding requirements to improve the tests, or to perform the work faster by partially automating it.

a low RH, *i.e.* 14%, while at 88% RH a reaction between image silver and residual thiosulfate will occur within a few weeks.[9]

Table 2 summarizes the results by Pope. They demonstrate well the significance of high relative humidity in bringing about chemical reactions. The residual thiosulfate content of poorly washed microfilm rolls, which were kept at three different RH levels, was measured regularly. At a relative humidity of 88% the measurable thiosulfate content decreases rapidly because it reacts with image silver and so becomes undetectable.

Fortunately, recommendations for suitable storage conditions for processed safety films have been published by ANSI.[10]

A type of deterioration particular to processed microfilm was discovered in the 1960s, extensively examined by researchers at the Eastman Kodak Company and the U.S. National Bureau of Standards, and widely reported upon.[11] The formation of microscopically small, orange-coloured spots — known today as redox blemishes — is well understood. They can easily be reproduced in the laboratory. In some reports these spots were called measles, an unfortunate term since it may suggest a disease, which could be contagious. That is of course not the case. Redox blemishes are caused by peroxides of known provenance. If the source of the peroxides is removed, deterioration will not continue. Cardboard boxes made from lignin-containing woodpulp have been identified as the culprits. Such materials produce gaseous peroxides during natural aging. The peroxides are capable of reacting with image silver to form circular orange-coloured spots of colloidal silver, a modification different from black image silver. They have been observed only on negative microfilm, *i.e.* camera original films, because of the high amount of silver present in those films. If film rolls are removed from cardboard boxes containing ground wood and placed into inert containers, the formation of redox blemishes will cease. It is the reason for the reboxing project at the Records Management Branch of the Public Archives of Canada.[12]

The above observation should not lead to the conclusion that paper or cardboard are generally unsuitable for the storage of processed photographic materials. Paper is highly recommended for the storage of photographic records if it meets certain requirements, such as a high alpha-cellulose content, neutral pH, absence of metal particles and sulfur-containing compounds, a minimum of sizing materials, etc. These requirements are laid out in yet another standard published by ANSI.[13]

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9 C.I. Pope, "Stability of Residual Thiosulfate in Processed Microfilm," *The Journal of Research of the National Bureau of Standards* 67C, no. 1 (1963), pp. 15-24.

10 American National Standards Institute, *American National Standard for Photography (Film) — Processed Safety Film — Storage.* ANSI PH1.43-1985 (New York, 1985). RH should lie between 30% and 50% for the storage of processed safety photographic film. RH must never exceed 60%. Recent evidence suggests that a level of 30 to 35% is optimum. Fluctuating RH must be avoided.

11 R.W. Henn and D.G. Wiest, "Microscopic Spots in Processed Microfilm: Their Nature and Prevention," *Photographic Science and Engineering* 7, no. 5 (1963), pp. 253-61; C.S. McCamy, *Inspection of Processed Photographic Record Films for Aging Blemishes* (Washington, 1964); C.S. McCamy and C.I. Pope, "Redox Blemishes — Their Cause and Prevention" *Journal of Micrographics* 3, no. 4 (1970), pp. 165-70.

12 Klaus B. Hendriks, "Occurrence of Redox Blemishes on Processed Microfilm at the Public Archives of Canada's General Records Centre (Records Management Branch)," *Records Management Bulletin* No. 2 (Autumn 1978), pp. 1-4.

13 American National Standards Institute, *American National Standard for Photography (Processing) — Processed Films, Plates, and Papers — Filing Enclosures and Containers for Storage.* ANSI/ASC PH1.53-1984 (New York, 1984).

No procedures have been published for the removal of redox blemishes from microfilm, *i.e.* for the restoration of films that have been affected. On the other hand, there have been very few cases of image loss.[14]

The stability of silver gelatin microfilm on cellulose ester or polyester film supports has been studied closely and is well understood.[15] There are no inherent disadvantages in the properties of microfilm as far as its stability is concerned. The built-in properties and the processing of microfilms, as well as the optimum storage conditions for these materials are — among all non-paper records — cleary defined by specifications published by ANSI and endorsed by the Canadian Standards Association. These standards have recently been reviewed.[16] If the conditions for processing and storage of microfilms, as defined in these standards, are met by the user, manufacturers are prepared to predict a useful life for microfilm in the order of centuries. Correctly processed and stored microfilm is as good as or better than paper with respect to permanence. Major national repositories have confirmed their commitment to the use of microfilm as a preservation medium.[17] For this application, camera original microfilm negative images (sometimes referred to as master copies) of valuable historical documents are used only for making positive user copies. The camera originals can be placed into inactive storage for many years without concern for their stability. They are taken out only for the purpose of making additional positive prints when the previous set has been worn out. The historical document itself need never be used in its original form.

The status of microfilm has recently received additional significance through the findings and recommendations of a subcommittee of the Committee on Preservation, established by the then U.S. National Archives and Records Services (NARS; it has since been renamed National Archives and Records Agency, NARA). The Subcommittee C had the objective to examine future recording technologies for use in NARS. It published a White Paper in July 1984, entitled: "Strategic Technology Considerations Relative to the Preservation and Storage of Human Machine Readable Records."[18] Based on the assumption that the top priority of the U.S. National Archives is the accession and indefinite preservation of valuable records, Subcommittee C recommended that NARA should formulate a preservation and storage strategy based on human readable microfilm. The reasoning for this approach is that all records should be stored in a human readable format in a certifiably archival medium. The various reasons that have led Subcommittee C to make this conclusion merit further study, which goes beyond the scope of these notes.[19]

14 Peter Z. Adelstein, "Preservation of Microfilm," *Journal of Micrographics* 11, no. 6 (1978), pp. 333-37.

15 *Ibid.*

16 Peter Z. Adelstein, "Status of Permanence Standards," *Journal of Imaging Technology* 12, no. 1 (1986), pp. 52-56.

17 Robert M. Warner, "Preserving the Records of America: The Role of Micrographics in the National Archives," *Journal of Imaging Technology* 10, no. 4 (1985), pp. 137-39; Alan Calmes, "Microfilm as a Preservation Medium," *Journal of Imaging Technology* 10, no. 4 (1984), pp. 140-42; Alan Calmes, "New Confidence in Microfilm," *Library Journal* 3, no. 15 (1986), pp. 38-42.

18 National Archives and Records Service. Advisory Committee on Preservation Subcommittee C, *Strategic Technology Considerations Relative to the Preservation and Storage of Human and Machine Readable Records.* White paper. (Washington, 1984).

19 John C. Mallinson, "Preserving Machine-Readable Archival Records for the Millenia," *Archivaria* 22 (1986), pp. 147-52.

Suffice it to say that the recommendation, made by technical experts from the manufacturing industries, to create a microfilm mass memory — called "an archival database of permanent records" — lends additional credibility to the usefulness of microfilm in pursuing the mandate of a national archive.

TABLE 1
Data on Processed Photographic Film to Be Recorded for Purpose of Monitoring

1. Manufacturer of film
2. Type of material: brand name
3. Type of processing; incl. name of processing laboratory
4. Date of processing
5. Residual thiosulfate level at time of processing and method used:
   (i) Methylene blue method
   (ii) Silver densitometric method } ANSI PH4.8-1985
   (iii) Iodometric method
6. Record of storage conditions (temperature, relative humidity, air purity)
7. Record of storage location
8. Type of container or filing enclosure

TABLE 2
Effect of Relative Humidity on the Concentration of Thiosulfate in Clear or Silver-Free Processed Microfilm During Aging at Room Temperature (20-30°C) Washed at 25°C for 3 Min.*

Relative Humidity	Sample	Thiosulfate, g/in.^{2}				
		Time After Processing, Days				
		0	27	50	185	279
14	a	23	23	23	23	23
53	b	23	23	23	23	23
88	c	23	18	15	5	2

* C.I. Pope (1963).