

STABILITY AND PRESERVATION OF
ARCHIVES MEDIA:
PAPER, PHOTOGRAPHIC MATERIALS
AND MAGNETIC RECORDINGS

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INTRODUCTION

Among the many types of records in various formats that can be found in archives - and in libraries as well - three generic media are predominant:

- PAPER:
in the form of manuscripts, books, maps, journals, and government papers;
- PHOTOGRAPHIC RECORDS:
in the form of historical still photographic negatives and prints; microfilm; motion picture film, and others; and
- MAGNETIC RECORDINGS:
in the form of sound tapes; video tapes; and computer magnetic tapes and disks.

These materials are mentioned here in chronological order: paper is the oldest, having made its appearance in Europe in the 13th century. While photography began in France and England a little more than 150 years ago, the magnetic recording of sound as we know it today was introduced in 1935 in Germany.

These media appear to be distinctly different with respect to their physical and chemical properties. Yet the separation between them becomes more blurred as information recorded in one medium can be copied readily onto another. Conventional examples are the microfilming of newspapers, or the photocopying of whole fragile books. Modern scanning techniques allow any form of information - whether pictorial or textual - be captured on a magnetic storage medium and converted back to a human readable format on photographic film or paper.

This paper examines:

- (i) the intrinsic stability of the three predominant information-carrying media;
- (ii) the storage conditions that are necessary to preserve them for long periods of time;
- (iii) the potential permanence of these materials, if they are made to certain well-defined specifications, in comparison with each other.

The preservation of these materials depends on their inherent permanence characteristics (which will be demonstrated later using the example of color photographs). The term preservation also includes the need for access to archival records, since there is no need to keep records of any kind if they cannot be used.

This requirement for records to be accessed will be shown to be a limiting factor in the preservation of magnetically recorded information.

PERMANENCE OF PAPER

The pulp and paper industry world-wide produces a variety of papers for specific uses: tissue papers; electrical insulating papers; roofing papers; packaging papers; newsprint, and many others. The present discussion focuses on the properties of the relatively small output of printing and writing papers. Of these only a fraction may be of interest to archivists and libraries if one considers products such as business forms, telephone directories, envelopes, advertising flyers and similar materials as expendable.

What is permanence of paper? The U.S. Technical Association for the Pulp and Paper Industry (TAPPI) has defined two terms to describe the stability of paper: permanence and durability. The former, in the words of TAPPI, is:

The degree to which paper resists chemical action which may result from impurities in the paper itself or agents from the surrounding air.

Durability, on the other hand, is defined as:

The degree to which a paper retains its original qualities under continual use.

While these terms are useful in describing a paper qualitatively as having the potential to be permanent, no quantitative measure is given that would indicate when a given paper is permanent, or when it may have passed a threshold value so as to have lost its permanence. For example, there is no technical definition of brittleness, the term most often used by casual observers to describe the condition of weakened paper. Consequently, no definition of an end point of brittleness has been defined beyond which paper has lost its usefulness. A book page too weak to withstand a single fold without breaking may still be useful, or functional, if it can be turned over and read.

An extensive amount of literature on the stability of paper has been published during the past 120 years. The publications range from general discussions, generally by archivists and libraries, on the alleged effects of temperature, relative humidity, and acidity on the longevity of paper, to technical articles presenting experimental data on the permanence of paper. Most complex, and disputed, is the question which mechanical or chemical test is indicative of the permanence of paper.

In spite of all these roadblocks, a combination of practical experience with many papers that have survived centuries and knowledge derived from published data allows the careful observer to conclude that a permanent paper, i.e., one resisting chemical changes and so keeping its strength properties for a long time:

- has a minimum caliper (thickness) and grammage;
- has a high α -cellulose content (>90%);
- contains no excess of alum if sized with alum rosin;
- contains preferably an alkaline size instead of alum rosin;
- contains no lignin;
- retains a number of physical properties after accelerated ageing.

None of the above is universally agreed upon. In particular, the contents-based specifications are frowned upon by manufacturers who are more inclined to accept minimum mechanical strength requirements, such as tensile strength, tear resistance, zero-span tensile strength and perhaps folding endurance. Yet experience has shown that a high α -cellulose content is a necessary prerequisite for a permanent paper. It is the most significant requirement which is corroborated by the fact that such papers are made to this day for applications that require a permanent paper, and for clients ready to pay premium price for it.

Papers with a high α -cellulose have traditionally been made from cotton or linen fibers. Such papers are loosely referred to as rag papers. However, they can also be made from purified chemical pulps, or fully bleached wood pulps. Since chlorine dioxide produces fewer aldehyde and carboxyl groups in the cellulose during the bleaching process, it is preferred over hypochlorites. Alpha-cellulose is that fraction of all cellulosic components which is chemically the most resistant. Cotton fiber consists almost entirely of α -cellulose, hence the stability of rag papers. It is clear then that the stability of any paper is a function of the stability of the cellulose it contains. Cellulose used in paper-making is taken out of a living organism: a plant or a tree. Any complex organic polymer that was designed by nature to function in a living organism is likely to be subject to a slow process of degradation once it is removed as part of that organism. Examples of such materials include wood, leather, bone, or ivory. It is the objective of efforts to keep paper documents for the long term to provide storage conditions that prevent, or slow down, the natural degradation of paper's main ingredient. Obviously this is easier to achieve if:

- the cellulose itself is of the highest grade;
- aggressive chemicals that may accelerate the process of degradation are absent from the paper.

The above may be summarized as the quality of paper: it is the single most significant factor to determine its permanence. Paper intended for printing and writing can be made in a variety of properties: from newsprint -- a fine example of one of the more ephemeral records materials -- to fine writing papers consisting of 100% cotton. There are numerous other examples of specific paper types made for permanence today. They all

have in common a high percentage of cotton fibers or α -cellulose plus any combination of the factors noted above.

The words printing and writing indicate that ink is required to record words on paper. The properties of printing and writing inks are the subject of a specialized field of study. They are not a subject of this paper. Rare are occurrences such as those caused by the notorious iron gall inks of a bygone era: chemicals forming part of the composition of these inks have reacted aggressively with the paper which becomes so brittle that, in some cases, holes are formed in the sheet where ink used to be.

The definition for permanence given by TAPPI neatly underscores the point that either impurities in the paper itself or aggressive chemicals from the surrounding air are the strongest enemy of paper. Examples of obnoxious chemicals in the paper may be certain sizes or residual bleaching compounds. Well established as external sources of trouble are sulfur dioxide and other gaseous acidic compounds. The absence of either of these is beneficial to the longevity of paper. Caution is advised when blaming all occurrences of fragile paper on its acidity. While it is true that most brittle papers are acidic, the opposite cannot be said to be correct: many papers exist with an acidic pH that are perfectly stable. The interpretation of any pH measurement is complex: it has a different meaning for different samples depending entirely on the age of the paper and the process by which it was made. To blame the lack of permanence of a given paper on its acidity would be a simplistic viewpoint: rather the source of the acidity and its real or potential effect on the paper's stability are the significant factors.

Permanence in the definition by TAPPI is a qualitative property. It does not attempt to determine a time period that a paper sheet must remain intact in order to be permanent. Nor does it explain a measurable end point beyond which a paper ceases to be permanent. These properties remain elusive. The best that can be done is to deduce from empirical observations the principal factors that determine the permanence of paper and, as a consequence of these factors, recommend suitable storage conditions for paper documents. That is summarized in TABLE 1.

**TABLE 1
THE PRESERVATION OF PAPER**

THE PERMANENCE OF PAPER IS AFFECTED BY:	RECOMMENDED CONDITIONS FOR LONG TERM STORAGE
Origin of fibers Purity of cellulose	Keep in pollution free environment:
Oxidizing agents Acidity from internal sources (e.g., alum rosin size), or from external sources (e.g., SO ₂)	SO ₂ : ≤ 1 µg/m ³ NO _x : ≤ 5 µg/m ³ O ₃ : ≤ 25 µg/m ³ CO ₂ : ≤ 4.5 g/m ³
High humidity expedites degradation reactions	Keep at: 20 ± 2°C and: 30 ± 5% RH
Light (esp. on groundwood papers)	Total suspended particulate: < 75 µg/m ³
Heat alone (at least within certain ranges) has little effect.	(Keep in the dark)

PHOTOGRAPHIC RECORDS

There is, generally speaking, a striking difference between paper and photographic records. The latter possess a *layer structure* which can easily be seen in a cross-sectional view. The two principal layers are the support and the image-forming layer. The vast majority of photographic images in existence – including microfilm, motion picture film, and X-ray film, and all color photographic pictures made by the chromogenic development process – have a support made of either a plastic film or paper, and an image-forming layer consisting of gelatin. The nature of these two components can be demonstrated nicely by their respective response towards changes in the surrounding relative humidity. In a dry environment, a silver gelatin photographic paper print curls up tightly towards the gelatin layer. If the relative humidity is changed to above 90%, the print will flatten out on its own. This behaviour illustrates the high reactivity of the gelatin layer towards moisture in comparison to that of the paper base.

Black-and-white photographs belong to the generic group known as silver gelatin photographic records. The 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 since the 1880s, the properties of silver gelatin photographic materials have been studied for more than one hundred years, first empirically and later, since the beginning of this century, in the research laboratories of various manufacturers.¹ Contemporary *color photographs* contain organic dyes as the image-forming substance in gelatin. By far the most common and commercially important processes employ the principle of chromogenic development, wherein the dyes that form the final image are chemically synthesized during development from colorless precursors initially present in the film layers. The majority of color slides, prints, motion picture films and all color negatives are made by this process. For the past decade or so, all major manufacturers in the world produced color prints generally on a resin-coated (RC) base.

The creation of black-and-white photographic records, such as microfilm, places an additional burden on archivists and librarians that is not necessary for paper and magnetically recorded media: the chemical processing of film and paper. 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.

The stability of photographic materials, as it does in paper records, depends on the inherent property of the components in a photograph and on the condition in which they are kept after processing. In addition, the processing (development, fixing, washing and drying) has, as noted, a marked effect on the stability of the image. Examples of inherent properties are, for the image-forming substance, the generally acknowledged superior stability of well processed silver photographs over that of organic dyes present in chromogenic color photographs; or regarding the support, the well-known instability of cellulose nitrate films in comparison to polyester film base. Apart from these examples, the manufacturing quality of contemporary photographic films and papers cannot be the subject of this article, particularly since the stability of these materials has been improved tremendously by manufacturers during the past decade or so. Rather, the stability of photographic images as determined by external factors is considered here.

¹ Numerous other support materials and binding agents have been used throughout the history of photography. Glass plate negatives, either made by the wet collodion process, or by silver-halide-in-gelatin technology are the most common after film and paper. Among materials widely used in the 19th century as binding agents are albumen (in photographic prints) and collodion on glass plate negatives and paper prints. Yet other rare images contained no separate image layer at all, such as salted paper prints and daguerreotypes. This section of the present article focuses on the properties of silver gelatin photographic materials.

In black-and-white photographs, the finely divided elemental silver that forms the image is generally the limiting component. It is liable to be oxidized to electrically charged silver ions by a variety of reactants. The most notorious of these are peroxides, nitrogen oxides, sulphur dioxide and ozone. Numerous instances have been reported of black-and-white images becoming discolored as a result of the presence of these chemicals. The effect of processing chemicals, especially that of the fixing salt sodium thiosulfate, is but a special case of the general susceptibility of processed silver particles to chemical oxidation reactions to form silver salts. It has received an extraordinary amount of attention in the general and technical photographic literature. The stability of silver gelatin photographic images is determined specifically by the absence of oxidizing chemicals that are necessary to bring about changes to the image silver. Such chemicals can, in rare cases, originate from within a photograph itself; from its immediate environment including filing enclosures and storage containers; and from residual processing chemicals. In the absence of aggressive chemicals capable of reacting with processed image silver, a silver gelatin photograph on a stable support has a life expectancy of several hundred years. Moisture and heat are generally controlled in the long term keeping of black-and-white photographs, because they accelerate degradation reactions, if oxidizing chemicals are present. Heat alone is not damaging to well-processed black-and-white photographs. Exposure to moderate levels of light does not cause an oxidation of the image silver to silver ions in a well-processed photograph, and therefore cannot lead to fading. However, photographs of any kind should be kept, without exception, away from exposure to direct sunlight.

The behavior of color photographs is a little more complex: the organic dyes that form the image can fade under the influence of light and, in contrast to black-and-white images, may lose density in the dark as well. The degradation of chromogenic dyes in the dark is temperature controlled and further affected by relative humidity. Consequently, the stability of color photographs is evaluated either under dark storage conditions ("dark fading") or as a result of exposure to light ("light fading"). Since different mechanisms of dye degradation occur in these two conditions, the visual result from fading in the dark is also different from that obtained in light fading. The three principal dyes necessary to construct all colors in a reflection print are cyan, magenta, and yellow. If, for example, the cyan dye in a color print is the least stable in the dark, its degradation would leave a proportionally higher amount of yellow and magenta in the image layer. Since the combination of yellow and magenta produces the visual impression of red, one recognizes the reason why color prints that have been kept in the dark have acquired an overall warm-reddish cast. Similarly, if magenta is the least stable dye in a color print when exposed to light, and so decreases in density after a while, the remaining dyes yellow and cyan would dominate the visual impression to form a blue-green overall tone. The need to keep color photographic images in the dark becomes clear now. It has been shown that color photographs should be kept in temperatures below zero degree Centigrade to alleviate dark fading. For example, a color slide kept at -18°C, the lowest temperature for which data have been published, will lose density of its limiting dye at a rate that is approximately 1000 times slower than that at room temperature, the relative humidity being equal in both cases. Control of relative humidity is further recommended as a preventive measure

against mold growth on gelatin layers. It should never exceed 60%. TABLE 2 summarizes the conditions that are necessary to produce and keep a stable photographic image.

TABLE 2 THE PRESERVATION OF PHOTOGRAPHIC IMAGES	
<u>BLACK-AND-WHITE (Ag)</u>	<u>COLOR (DYE)</u>
A STABLE PHOTOGRAPH: IS WELL PROCESSED IS ON A STABLE BASE (POLYESTER FILM; FIBER-BASE PAPER; RC PAPER FOR COLOR) HAS A BINDING LAYER OF GELATIN IS KEPT IN A POLLUTION-FREE ATMOSPHERE IS KEPT AT STABLE RELATIVE HUMIDITY: 30±5% IS KEPT OUT OF DIRECT SUNLIGHT IS KEPT IN STABLE, INERT ENVELOPES	
IS KEPT AT A STABLE TEMPERATURE: 15 - 24°C	IS KEPT IN THE DARK IS KEPT IN COLD STORAGE: -18°C [AT CONTROLLED R.H.]

MAGNETIC RECORDINGS

A discussion of magnetically recorded information enters the realm of machine readable records. That is a significant statement because it carries with it wide-ranging implications. *Human readable* records can be read and understood with the human eye including simple optical projection or magnification e.g., a photograph, a book, a map. By contrast, *machine readable* records can only be read and understood by means of a machine (and the human eye), e.g., a videotape, an optical disk, a 1/2-inch computer tape. All digital recording is machine readable. Analogue may be machine or human readable. Because the tendency of technology is to achieve greater speed of access and capacity, all storage densities are increasing. There are spectacular benefits to storing information in electronically digital form. It permits fast access; very high density storage; transmission of data by telephone lines; and the manipulation of the signal, often referred to as "signal enhancement" or "image enhancement". However, the long term keeping of such records is fraught with inherent difficulties because of their particular properties. At the center of these difficulties are not only the physical properties of tapes and disks, their component parts and their preservation, but the maintenance of the associated software necessary to gain access to the information. The maintenance of data that is regularly revised and updated further complicates the matter. More significant than the problem of the stability of tapes and disks is the question: how is future access to data achieved in the face of

rapidly changing devices that record and play back the information? These machines are commonly known as hardware. The machines that are necessary to play back machine readable records are a main source of the problem. The pace of technology is such that the expected planned useful life of electronic devices is less than 20 years. Within 20 years, a manufacturer will abandon maintenance of a machine. This obviously jeopardizes access to machine readable records.

The pace of technology can be observed readily by looking at the changes to generally known recording media during a life-time, i.e., the last 30 years. Conventional music disks, for example, have changed from 78 revolutions per minute (r.p.m.) via 45 r.p.m. to the long-playing records of 33 r.p.m. The latter have now largely been replaced by compact disks (CDs). Similar changes in video tape format that have occurred since 1956 are listed in TABLE 3, along with changes in format and capacity of computer tapes, which are shown in TABLE 4. Further, the astonishing increase in packing density of magnetic storage media is shown in TABLE 5.

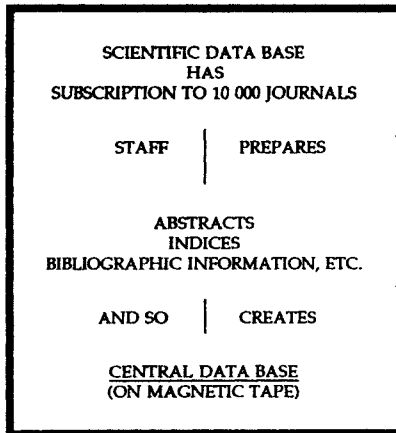
TABLE 3 SOME CHANGES IN VIDEO TAPE FORMATS SINCE 1956
TWO INCH QUAD DOUBLE DENSITY TWO INCH QUAD TYPE A HELICAL TYPE B HELICAL THREE-QUARTER INCH U-MATIC HALF-INCH BETAMAX HALF-INCH VHS EIGHT-MILLIMETER TAPE
SOURCE: J.C. Mallinson

TABLE 4 CHANGES IN FORMAT FOR HALF-INCH COMPUTER MAGNETIC TAPE
100 BPI 7-TRACK 200 BPI 7-TRACK 560 BPI 7-TRACK 800 BPI 7-TRACK 1,600 BPI 9-TRACK 3,200 BPI 9-TRACK 6,250 BPI 9-TRACK 19,000 BPI 18-TRACK
SOURCE: J.C. Mallinson

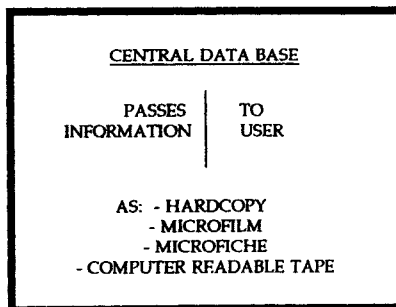
TABLE 5 DISK DRIVE HISTORY				
YEAR	PRODUCT	LINEAR BIT DENSITY (bpi)	TRACK DENSITY (tpi)	AREAL DENSITY (MB/IN ²)
1957	IBM 350	100	20	.002
1961	IBM 1405	220	40	.009
1962	IBM 1301	520	50	.026
1963	IBM 1311	1025	50	.051
1966	IBM 2314	2200	100	.22
1971	IBM 3330	4040	192	.78
1973	IBM 3340	5636	300	1.69
1976	IBM 3350	6425	478	3.07
1979	IBM 3370	12134	635	7.8
1981	IBM 3380	15000	801	12
1984	IBM 3380 (E)	15000	1400	21
1987	IBM 3380 (K)	15000	2050	30.75
1990	IBM 3390			58
Source: J.C. Mallinson				

It is fascinating to look into the reasons why the use of magnetically recorded digital data is so attractive in many applications. A specific example demonstrates their use:

A scientific data base in the U.S.A. collects and abstracts about 10, 000 technical journals (i.e., 10, 000 different titles) annually. Abstracts and bibliographical data are fed into a data base stored on magnetic tape according to the following scheme:



Data from the data base is passed on to the user in various output forms:



The data are highly secured, as there exist four copies of each tape, one of which is stored in an out-of-town location. The security copies are rotated back periodically into use for monitoring purposes. To summarize the outstanding characteristics of this scientific data base, it features:

- high density storage;
- fast access to data;
- on-line access by outside users;
- delivery of data in various media;
- security of data.

The rapid changes in the format of computer tapes was noted earlier. How does the scientific data base cope with the inevitable progress in magnetic data recordings? TABLE 6 illustrates their response:

TABLE 6
CONVERSION OF HARDCOPY DATA TO COMPUTER-STORED DATA IN SCIENTIFIC DATA BASE

YEAR	STORAGE DENSITY	NUMBER OF TRACKS	TOTAL NUMBER OF TAPES
1967	550 BPI	7-TRACK	?
1970s	800 BPI	7-TRACK	?
early 1980s	1,600 BPI	9-TRACK	4-6000
1987	6,250 BPI	9-TRACK	4-6000
since 1987	38,000 BPI (CARTRIDGE TAPE)	18-TRACK	4-6000 (DATA BASE PROPER)

BPI = BITS PER INCH

Automation began in 1967. As new tape formats appeared, *file conversion* to the new format followed concurrently. One truly amazing result is the observation that the total number of tapes remained constant: as the amount of data collected for the data base increased exponentially as a result of scientific research, so did the storage capacity of magnetic tapes (cf. TABLE 5)! The ongoing file conversion (sometimes called: transgression of data; data transfer to another format; or plain copying) practiced by this particular data base alleviates all concerns regarding the suspected lack of permanence of magnetic recordings (in comparison to records on paper and photographic film).

What distinguishes the operating mode of such a data base from similar collections in archives? Obviously, the data available from the scientific data base are in high demand. Secondly, the users pay for access to the data, so providing necessary funds for the file conversion. In other words, the scientific data base is user-driven. As an added bonus, its high use also ensures the constant monitoring of the integrity of data.

The data base is located in the Technical Division of the Chemical Abstract Service (a part of the American Chemical Society) in Columbus, Ohio.

SUMMARY

The foregoing notes have neither included *parchment* or *vellum* nor, on the near end of the time scale, optical disk technology for the storage of data. Experience going back many centuries has shown that parchment and vellum have excellent permanence characteristics. It has been the intention of this article to show that *paper records* also have

the potential to meet certain criteria for permanence. That is determined to a large degree by the materials used in their manufacture. Various paper qualities cover a wide range: from so-called rag papers, containing a high percentage of pure cellulose and sizes, to newsprint, that is literally made for the day ("journal") and produced from unstable groundwood. The potentially excellent permanence characteristics of paper are well established. If manufactured to known and established standards and stored at equally accepted conditions, paper should demonstrate its superior stability for many centuries. Well-processed *silver gelatin photographs* on polyester film (as well as on fiber-base paper) are expected to survive for well over 1000 years if kept protected from aggressive chemical substances. Currently produced *color photographic images* can be expected to maintain acceptable color contrast and color balance for several hundred years, if kept in the dark at -18°C (0°F) and 30 percent RH. On the other hand, *machine readable records* need machines to be read and understood. Knowledge of the stability of magnetic recordings is fragmentary, and the permanence of *optical digital disk* recording remains a subject of conjecture. While digitally recorded data have several attractive properties as noted, long archival life has not been found to be one of the relevant characteristics of data so recorded. Magnetic and optical disk recordings are generally considered to be suitable for the storage of transitory data. That is the message conveyed in TABLE 7, which also links the criteria of *intrinsic value* of a document to its *permanence*. The concept of the intrinsic value of a

MEDIUM	VINTAGE	ACCESS	INTRINSIC VALUE	KNOWN PERMANENCE	APPLICABLE CONCEPT
PARCHMENT	> 1000 YEARS	HUMAN READABLE	YES	EXCELLENT	PERMANENCE
PAPER	CENTURIES	HUMAN READABLE	YES	EXCELLENT BEFORE 1800s	PERMANENCE
PHOTOGRAPHIC IMAGERY	150 YEARS	HUMAN READABLE	YES	B/W:EXCELLENT COLOR:ACCEPTABLE WITH SPECIAL PRECAUTIONS	PERMANENCE
MAGNETIC RECORDINGS	ABOUT 50 YEARS	MACHINE READABLE	YES	POOR	DATA LIFE
OPTICAL DISKS	ABOUT 10 YEARS	MACHINE READABLE	YES	UNKNOWN	DATA LIFE

record, developed by the U.S. National Archives, may further clarify the use and preservation of records. Records may or may not possess intrinsic value, depending on their age, physical form, esthetic or artistic quality, unique physical features, and direct association with historically significant people or events. The application of these criteria to all types of records demonstrates that those which have intrinsic value are almost invariably human readable. Conversely, machine readable records, particularly those in

digital form, rarely have intrinsic value (the exception being perhaps analog sound recordings). Because the majority of machine-readable records can be copied easily and economically for preservation purposes, the concept of *permanence* is giving way to that of *data life*. Parchment, paper, and photographic film are human-readable records which often have intrinsic value; the concept of permanence applies to them because of their excellent and known stability characteristics. Magnetic recordings and digital optical data recordings on disks are machine-readable only and rarely possess intrinsic value. Since their known permanence characteristics are inferior to those of conventional records, the concern for data life or data integrity supersedes that for permanence.

Since the concept useful in the preservation of machine readable records is data life, the principal objective is not the preservation of the original record, but that of the information. That can be done by copying the information onto a more advanced version of the same system (as was shown for the scientific data base), or onto a new system, for example transferring data from magnetic tape to an optical disk.

The concept of *permanence*, being a noble and indisputable one, is difficult to fill with substance and concrete meaning. There are no precise ways of measuring permanence, only qualitative indicators. The tendency is therefore to replace it with the term *life expectancy*. This would allow to attach years or centuries of usefulness to a given records material which is more realistic than saying that certain documents must be retained forever. It should be exciting to observe and perhaps to take part in future developments in the area of longevity of archival records.

ACKNOWLEDGEMENTS

The reader who wishes to examine in more depth the topics discussed on the foregoing pages is referred to chapter 20 in the recently published volume: Imaging Materials and Processes: Neblette's Eighth Edition, Van Nostrand Reinhold, New York: 1989. It is entitled: "The Stability and Preservation of Recorded Images". The author acknowledges gratefully useful discussions with Dr. John C. Mallinson, Centre for Magnetic Recording Research in La Jolla, California, on the permanence of magnetic media. Much of the knowledge presented here was drawn from his lectures and articles.