NBSIR 76-991

Evaluation of Transparent Electro-Photographic Film and Camera System

Thomas C. Bagg

Computer Systems Engineering Division
Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, D.C. 20234

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U.S. DEPARTMENT OF COMMERCE, Elliot Richardson, Secretary Designate
James A. Baker, III, Under Secretary
Dr. Betsy Ancker-Johnson, Assistant Secretary for Science and Technology

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Acting Director

Foreword

For a number of years, photographic recording materials with add-on capabilities, i.e., ability to add images to the original at a later time, have been discussed and demonstrated in the laboratory.

Recently, one of these materials, the transparent electrophotographic (TEP) medium, was used as the basis for a prototype camera-film system. Since there are many files requiring an add-on microrecording system, the Naval Supply Systems Command obtained a prototype TEP system for a feasibility study. The prototype equipment was installed in the Navy Publishing and Printing Branch at the Headquarters Building, Washington Navy Yard; and the National Bureau of Standards was requested to assist in its evaluation.

Evaluating new materials and equipment for routine use requires development of test procedures and extensive observations. This is an interim report covering the initial observations.

The growing awareness of add-on film systems has created wide interest by both users and potential suppliers. These groups are also testing similar and other types of add-on material resulting in the availability of additional data. As data from further tests and observations becomes available, additional reports will be made on such materials, particularly the TEP type.

The Archivist of the United States has the responsibility for the recording of Federal records and is deeply concerned with utilizing the most efficient methods; he is therefore cooperating in this evaluation by having the Chief of the Technical Services Division of the National Archives and Records Service work with NBS on this evaluation.

Table of Contents

Evaluation of TEP Film and Camera System
Interim Report to Naval Supply Systems Command

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On behalf of the Naval Supply Systems Command, the National Bureau of Standards was requested to assist in the evaluation of new microfilm techniques and materials which permit the adding-on of images at various times. This is an interim report on the initial evaluation of the AB Dick/Scott System 200 which uses transparent electrophotographic materials.*

Key words: Add-on films; information storage; microforms; transparent electrophotographic material.

Introduction

In an effort to utilize the many advantages of microforms for the management of current files, a number of systems have been proposed and developed as substitutes for the file jackets containing papers. Adding documents to a file jacket is a relatively simple manual operation. It is, however, time consuming, leads to voluminous files, and is highly vulnerable to errors due to misfiling. Further, due to its bulk, it is impractical to be duplicated so items must be withdrawn from the file for varying periods of time which frequently creates delays for other users and destroys file integrity. The more active a file, such as those containing correspondence, personnel actions, medical histories, directives, etc., the more serious the above mentioned problems become.

A properly designed and operated microform system can overcome many of the difficulties by improving accessibility, reducing retrieval time, maintaining file integrity by permitting inexpensive duplicates, reducing storage space and costs, etc. However, most microfilm systems do not allow convenient file expansion or have add-on capability. In the past, systems using microfilm jackets, i.e., transparent cards with pockets into which microimages may be slipped or transparent cards to which individual document images may adhere, have been developed and used. Such systems are expensive and require considerable manual effort.

The ideal solution would be the use of a film to which images could be added whenever required. Therefore in recent years, several films have been announced using processes for vesicular emulsions, thermoplastic, transparent electrophotographic materials and diffusion transfer techniques. Of these, the Scott transparent electrophotographic (TEP) film and camera system appeared, in late 1974, to be the most advanced (now AB Dick/Scott - System 200). In an effort to use the best advanced technology, the Naval Supply Systems Command installed a prototype System 200 for feasibility tests in the Navy Publication and Printing Branch. The goals of this study would be guidelines for the use of add-on microfilm systems for the effective handling of active files.

The National Bureau of Standards was asked to assist the Naval Supply Systems Command in evaluating the AB Dick/Scott System 200 in the following three areas:

1. Image quality
2. Systems operation
3. Manufacturer's test results for determining the life expectancy of imaged and unimaged film.

Description of Transparent Electrophotography (TEP)

Basically, the film is a transparent polyester sheet coated with a transparent electrical conducting material containing light sensitive compounds. This coating can be electrically charged over an area the size of a single microimage frame. It is then exposed through

*Commercial designations are provided for purposes of objective identification. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that these products are necessarily the best for the purpose.

a lens in a conventional way to light reflected from a document. The electrical charges are dissipated in the areas receiving light but not in the areas representing printed information, thereby forming a type of latent image. Very fine carbon particles oppositely charged are passed over the exposed area and adhere only to the remaining charged areas in the image. These particles are permanently fixed to the film by radiant heat, resulting in a positive image. This is all done frame-by-frame so that uncharged, unexposed, and unprocessed areas can at a later time be treated as described to form images. Previously exposed and processed frames can be re-exposed and reprocessed to add small amounts of information or, if needed, add the word "VOID" to the original image by overprinting. The principle of this system is similar to xerography or electrofax but uses reduced images and very fine toning materials.

To complete a system, Scott designed and built a camera which automatically exposes the document to TEP film sheets cut to standard microfiche size and processes the images as outlined above. This camera also automatically moves the microfiche from frame-to-frame during recording operations. For add-on images, the operator can set the camera to the desired frame location prior to exposure. To prevent accidental double exposure, the camera has a special sensor which detects an image in a frame and signals the operator so that no exposure will be made unless specifically instructed.

Results of Observations

The evaluation could not be completed within the time anticipated. Therefore, this interim report presents the data obtained to date in each of the areas to be examined.

(1) Image quality -- Test targets and a series of document sheets, representing a wide assortment of information that was difficult to record, were recorded by the System 200 and examined for system response and image quality.

a. Resolution -- The NBS 1010A Microcopy Resolution Test Charts were recorded by three cameras on several occasions. The images were made with the Navy camera, a similar camera at the Army Security Agency, and a model in the Scott laboratory. Typical data obtained is shown in the following table:

Camera	Smallest Pattern Resolved	Reduction Ratio	Resolving Power of System
Laboratory Model	4.0 lines/mm	27.4	110 lines/mm
Navy	4.5	23.9	108
ASA	3.6	26.6	96

It should be noted that some frames resolved the 5.0 l/mm throughout and that the tests above were made on films currently available and do not reflect claimed improvements in new film coatings. Additional resolving tests will be made when new materials become available.

b. Tonal Range (gray scale, density, contrast) -- The density of the base and coatings in a clear area is about 0.35. When coated with a toner, the image area can reach a density of at least 1.60. This gives an image contrast of about 1.25, which is well above the level needed to make suitable second generation prints on conventional duplicating films.

Due to field effects of the electrical charges, toner particles are not held uniformly across large dark areas, thereby creating a lessening of the image density in the center of large dark areas. Images of round solid areas of up to about 35mm in diameter seem to show a minimum of charge loss and coat reasonably uniformly. Preliminary tests showed 5 or 6 shades of gray could be recorded from a 7 step reflectance wedge. These included the clear and black areas. Additional tests using wedges with more steps and steps of different sizes are planned.

c. Self-Compensation for Non-White Documents -- Because the initial or latent image is formed by electrostatic charges, there appears to be some self-adjusting for exposure when recording documents with different background reflectivities due to color or discoloration of the paper. A group of sheets having a wide variation in paper colors and contrast with ink were recorded on TEP films and conventional silver halide microfilm to

obtain an indication of this effect. With the TEP film, using a constant exposure, images of good contrast were formed for documents having good contrast between the ink and the paper, regardless of color. Except for the dark color papers, the background on the TEP images appeared white. The darker papers showed some grayishness having a density of 0.44 which did not interfere with readability.

With silver halide film, the exposure had to be increased to compensate for the reduced background reflectiveness of the darker papers.

Very light colored inks (light gold, light yellow, light orange, etc.) on light papers frequently produced very light images with TEP, whereas the images on silver films were slightly better if the exposure was readjusted.

Pictorial information with mostly dark tones or colors was difficult to record on silver films; however, the TEP films produced quite acceptable images at the fixed exposure.

(2) Operation of the System -- The system installed at the Navy Yard seemed, after appropriate adjustment, to operate reliably and to be convenient for the operator.

In addition, operational data was obtained from tests on two other systems. One was another prototype system observed in a New York bank. This camera was operated daily by a variety of inexperienced and disinterested operators who were adding approximately 2,200 images per day with an average add-on of three pages per fiche. Further, the supervisors who were observed, appeared careless in how they handled the master fiche when making duplicates for the account managers. Despite this lack of concern, the camera continued to operate reliably and the images were quite satisfactory for the users' needs. It was noted that occasionally, add-on images did not form properly on areas with heavy fingerprints, a characteristic of most photosensitive materials.

The Army Security Agency (ASA) system is used for pilot tests to record financial and travel records. The supervisor and camera operator liked the system very much and the operator seemed to have no difficulty in recording a variety of documents, some of which were poor, having been made on improperly adjusted office copy machines. Obviously some of these sheets cannot produce good images, but this is a fault of the original copy rather than the system. However, the self-compensating feature of the system appears to enhance some poor copy. The operator says that she has had very little trouble with the system and when there has been something that required adjustment, a serviceman was available for repair. These services were rare and only a few of them required shutting down the system. The most serious problem was due to a failure of the liquid toner mechanism. Since the System 200 is prototype, it is to be expected that difficulties will develop which require further work.

(3) Archival and Keeping Quality of Film -- Since this is a new type of photosensitive material to be used for initial document recording over a period of time, there is great interest and concern in the shelf life of the unimaged material and the permanence of the final images.

The film base is a polyester material which has been approved for use in permanent record films (ANSI PH1.41-1973, Specifications for Photographic Film for Archival Records, Silver Gelatin Type and Polyester Base). The image is composed of carbon particles which are inert. However, the stability and/or life expectancy of the binder used and the photosensitive compounds in the TEP coating have not been fully tested.

To obtain data on the permanence of imaged materials, members of the Scott staff and the Director of Technical Services of the Archives met with NBS and outlined a program which Scott would follow with the results submitted to NBS and the National Archives and Records Service (NARS). Applicable tests and procedures were taken from ANSI Standards PH1.25-1974, Specifications for Safety Photographic Film; PH1.28-1973, Specifications for Photographic Film for Archival Records, Silver Gelatin Type, on Cellulose Ester; PH1.41-1973, Specifications for Photographic Film for Archival Records, Silver Gelatin Type and Polyester Base and certain pertinent tests from a draft standard for determining the permanence of non-silver materials.

These tests represented a substantial amount of laboratory work; therefore, AB Dick/Scott employed an independent testing laboratory familiar with testing photographic films to assist them. Preliminary tests and measurements indicated that further testing was necessary before conclusive results could be reported. Such tests are underway.

The AB Dick/Scott position on these tests is stated in a letter from David Wolf, Vice President in charge of marketing, dated August 22, 1975, copy attached. "While the results are generally positive, test methodology in two areas made measurements difficult and results subject to question. Additionally an anomaly not previously observed in the sample of aged film warrants clarification and further study." Of major importance is the fact that much of the inconclusive data appears related to the polyester film based material. The results of these measurements will be of great concern to coaters of materials on polyester other than the TEP.

None of the standards for archival films contain a scratch or abrasion test because such films are to be carefully handled and not subjected to abuse. However, an add-on film will be handled more than a film stored in an archive. To estimate the abrasion resistance of TEP compared to silver, a pencil eraser and a knife blade were run over each emulsion. Very light pressure of an eraser produced very little effect on either, but as the pressure was increased, the images on the TEP could be abraded slightly more than the silver images. The knife point required about the same pressure to cause an effect of about the same magnitude and then it really cut a groove in both materials. This was a very subjective comparison. However, it appears the TEP image, when compared to a silver image, can adequately withstand the type of handling recommended for all master negative materials.

Although the archival keeping properties of imaged areas appears to comply with Federal requirements for master silver images when properly handled and stored, there is uncertainty over the longevity of the sensitivity of non-imaged areas when the master TEP film is used as a working copy. Prolonged exposures to high intensity light, such as found in reader film gates and certain duplicators, will affect the film's ability to accept new images. Each package of film contains such a warning as well as recommendations for the film's use.

The manufacturer states that a full fiche can be duplicated at least 100 times (number of copies per fiche) without failure of the imaging properties and believes the imaging life, when the film is handled as recommended to be at least 20 years.

Further tests are required to definitively substantiate these claims and some simple tests are being developed and tried in an effort to determine the imageability life.

Summary

Preliminary observations of system operations and tests of image quality and life expectancy indicate the TEP system can adequately perform the function for which it was designed; that is, to produce a master copy with add-on image capability.

Because of the new technologies used in add-on film systems, evaluation tests and procedures must also be developed. Such effort is being carried on by several laboratories and as significant data on the performance of these materials becomes available, it will be analyzed and the results reported.