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ANSI/AIIM MS43-1998

STANDARD

Standard Recommended Practice—

Operational Procedures—

Inspection and Quality Control of Duplicate Microforms of Documents and From COM

ANSI/AIIM MS43-1998

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Standard for Information

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Standard Recommended Practice — Operational Procedures — Inspection and Quality Control of Duplicate Microforms of Documents and From COM

Association for Information and Image Management International

Abstract:

This document provides guidelines for the production of duplicate microforms. This practice does not apply to special technologies such as ultra-high reduction ratios and duplication of color microforms.

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Foreword

(This foreword is not a part of *American National Standard for Information and Image Management — Standard Recommended Practice — Operational Procedures — Inspection and Quality Control of Duplicate Microforms of Documents and From COM* — ANSI/AIIM MS43-1998.)

This is a companion to *American National Standard for Information and Image Management — Standard Recommended Practice — Production, Inspection, and Quality Assurance of First-generation, Silver Microforms of Documents* — ANSI/AIIM MS23-1997; *American National Standard for Information and Image Management — Recommended Practice for Alphanumeric Computer-Output Microforms — Operational Practices for Inspection and Quality Control* — ANSI/AIIM MS1; and *American National Standard Recommended Practice for Operational Procedures, Quality Control and Inspection of Graphic Computer-Output Microforms* — ANSI/AIIM MS39. This revision was prepared in 1995 and 1996.

The purpose of this practice is to describe and recommend test media, measuring, and inspection procedures to establish adequate quality for producing duplicate microforms. Microfilm quality is determined and controlled by adequate inspection, which includes evaluation of workmanship, equipment performance, and materials measured by accepted standards. Existing ISO, ANSI, and ANSI/AIIM standards provide some of the basic test methods and quality assurance provisions for this document. In some cases, where an accepted standard test method is not yet available, this document recommends tests and methods in general use that laboratory or field tests or both have indicated to be effective.

Many specific uses of microfilm require higher levels of quality than are indicated in this standard practice. However, certain minimum quality standards must be maintained to ensure microfilm quality adequate for general use, and this standard sets forth such minimum quality standards.

Sample inspection forms are included in informative annex A. Readers are encouraged to copy these forms and use them with their microfilm systems. Helpful tools and information are included in informative annex B.

Suggestions for improvement of this standard are welcome. They should be sent to the Chair of the AIIM Standards Board, Association for Information and Image Management International, 1100 Wayne Avenue, Suite 1100, Silver Spring, Maryland 20910-5603.

This standard was developed under the auspices of the AIIM Standards Board, which approved it as an Association for Information and Image Management Recommended Practice. The Standards Board had the following members at the time it processed and approved this standard.

Name of Representative	Organization Represented
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American National Standard for Information and Image Management —

Standard Recommended Practice —

Operational Procedures —

Inspection and Quality Control of Duplicate Microforms of Documents and From COM —

ANSI/AIIM MS43-1998

1 Scope

This document provides guidelines for the production of duplicate microforms. This practice does not apply to special technologies such as ultra-high reduction ratios and duplication of color microforms.

2 References

All standards are subject to revision. When the following documents are superseded by an approved revision, that revision may apply.

2.1 Referenced American National Standards

ANSI/NAPM IT9.1-1996, *Imaging materials — Processed silver-gelatin type black-and white film — Specifications for stability.*

ANSI/NAPM IT9.5-1996, *Imaging materials — Ammonia-processed diazo photographic film — Specifications for stability.*

ANSI IT9.6-1991, *Photography — Photographic films — Specification for safety film.*

ANSI/NAPM IT9.11-1993, *Imaging Media — Processed Safety Photographic Films — Storage.*

ANSI/NAPM IT9.12-1995, *Imaging material — Processed vesicular photographic film — Specifications for stability.*

ANSI/NAPM IT9.13-1992, *Imaging Media-Photographic Films, Papers, and Plates-Glossary of Terms Pertaining To Stability.*

ANSI/NAPM IT9.17-1993, *Photography — Determination of residual thiosulfate and other related chemicals in processed photographic materials — Methods using iodine-amylose, methylene blue and silver sulfide.*

ANSI/AIIM MS1-1996, *Information and image management — Recommended practice for alphanumeric computer-output microforms — Operational practices for inspection and quality control.*

ANSI/AIIM MS11-1987 (R1993), *Information and image management — Microfilm jackets.*

ANSI/AIIM MS20-1990, *Information and image management — Readers for transparent microforms — Performance characteristics.*

ANSI/AIIM MS23-1991, *Information and image management — Microfilm of documents, operational procedures/inspection and quality control of first-generation silver-gelatin.*

ANSI/ISO 5-2:1985, *Photography — Density measurements — Part 2: Geometric conditions for transmission density.*

ANSI/ISO 5-3:1995, *Photography — Density measurements — Part 3: Spectral conditions*

ANSI/NAPM IT2.18-1996, *Photography — Density measurements — Part 3: Spectral conditions.*

ANSI/ISO 3334:1991, *Micrographics — ISO resolution test chart no. 2 — Description and use.* (Same as ANSI/AIIM MS51-1991.)

ANSI/AIIM TR34-1996, *Sampling Procedures for Inspection by Attributes of Images in Electronic Image Management (EIM) and Micrographics Systems.*

2.2 Other referenced standards

ISO 2859, *Sampling procedures and tables for inspection by attribute.*

2.3 Related standards

ANSI IT9.2-1991, *Imaging media — Photographic processed films, plates, and papers — Filing enclosures and storage containers.*

ANSI/NAPM IT9.7-1993, *Photography — Photographic films and papers — Wedge test for brittleness.*

ANSI PH1.51-1983, *Micrographic sheet and roll films, dimensions for.*

ANSI IT7.224-1991, *Audiovisual systems — Photography (Slide projectors) — Determination of temperature rise in the picture area using a glass sandwich test slide.*

ANSI/AIIM MS34-1990, *Information and image management — Dimensions for reels used with processed 16-mm and 35-mm microfilm, not for use in automatic threading equipment.*

ANSI/AIIM MS5-1992, *Information and image management — Microfiche.* (1997 revision is in process.)

ANSI/AIIM MS8-1988, *Information and image management — Image mark (blip) used in image mark retrieval systems.*

ANSI/AIIM MS9-1987 (A1996), *Information and image management — Method for measuring thickness of build-up area on unitized microfilm carriers (aperture, camera, copy, and image cards).*

ANSI/AIIM MS10-1987 (R1993), *Information and image management — Method for determining adhesion of protection sheet to aperture adhesive of unitized microfilm carrier (aperture card).*

ANSI/AIIM MS14-1996, *Information and image management — Specifications for 15 mm and 35 mm roll microfilm.*

ANSI/AIIM MS15-1990, *Information and image management — Dimensions and operational constraints for single-core cartridge for 16-mm processed microfilm.*

ANSI/AIIM MS16-1981 (R1993), *Information and image management — Dimensions and operational constraints for double core (bi-axial) cassette for 16-mm processed microfilm..*

ANSI/AIIM MS18-1992, *Information and image management — Splices for imaged film — Dimensions and operational constraints.* (Revised in 1997.)

ANSI/AIIM MS19-1993, *Information and image management recommended practice — Identification of microforms.*

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ANSI/AIIM MS41-1996, *Information and image management — Dimensions — Unitized microfilm carriers (aperture, camera, and copy).*

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ANSI/ISO 6328:1982, *Photography — Photographic materials — Determining ISO resolving power.*

CAN2-72.11-79, *National Standard of Canada —Microfilm as documentary evidence.*

2.4 Other related publications

AIIM Microform Indexing and Retrieval Systems, CS4-I975. Out of print.

ANSI/AIIM TR2-1998, *Technical Report for Information and Image Management — Glossary of Document Technologies.*

AIIM TR4-1989 (A1993), *Technical Report for Association for Information and Image Management — Silver Recovery Techniques.*

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Fundamentals of Microfilm Duplication Seminar. Proceedings of the Seventeenth Annual Meeting and Convention. Silver Spring, MD: Association for Information and Image Management, 1968, pp. 247-266.

McCamy, C.S. *On the Information in a Microphotograph.* Applied Optics 4. (April, 1965): pp. 405-411.

Micrographic Film Technology, Second Edition. Silver Spring, Md.: Association for Information and Image Management, 1983.

Microfilm in the Office: An Introduction to Microcopying. London, England: British Standards Institution, 1972.

Nixon, Hargrave, Devans & Doyle. *Admissibility in Evidence of Microfilm Records.* Rochester, New York: Eastman Kodak Company, 1971.

OSHA 1910. 111, *Storage and Handling of Anhydrous Ammonia*. 29 CFR l7, 7187 addition, 1987.

SMPTE RP 20-R1975, *Recommended Practice Specifications for 16 mm Registration Test Film.*

Thomas Woodlief. *SPSE Handbook of Photographic Science and Engineering.* Microphotography. 1973: 1181-1247.

3 Definitions

Definitions relating to this standard can be found in the ANSI/AIIM TR2.

Definitions of the film defects are expanded slightly for use with this practice.

3.1 archival medium: A recording material that can be expected to retain information forever so that it can be retrieved without significant loss when properly stored. However, there is no such material and it is not a term to be used in American National Standards material or system specifications.

3.2 bimodal: The capability of a reader-printer to produce positive-appearing paper prints from either positive- or negative-appearing microfilm.

3.3 direct-image film: A film that will retain the same polarity as that of the previous generation or the original material; that is, tone for tone, black for black, white for white, negative for negative, or positive for positive with conventional processing.

3.4 extended-term storage conditions: Storage conditions suitable for the preservation of record information having permanent value.

3.5 Life Expectancy (LE): The length of time that information is predicted to be retrievable in a system under extended-term storage conditions.

3.6 LE designation: A rating for the life expectancy (LE) of recording materials and associated retrieval systems. The number following the LE symbol is a prediction of the minimum life expectancy in years for which information can be retrieved without significant loss when stored under extended-term storage conditions; e.g., LE 100 indicates that information can be retrieved after at least 100 years of storage.

3.7 medium-term storage: Storage conditions suitable for the preservation of recorded information for a minimum of 10 years.

4 Duplication system requirements

To produce quality film duplicates, the following must be clean:

— master films;

— duplication films;

— duplicators;

— environment of the duplication and quality control/inspection work rooms and workplace.

All films should be handled only when using lint-free gloves. Smoking and any contaminants such as food, beverages, hand lotion, and so on should not be allowed in these areas.

A number of factors must be considered when choosing the type and quality of duplicating film for a specific application. Today there are three major types of sensitized materials used for duplicate microforms. They are diazo, silver, and vesicular.

The major factors that should be considered when selecting a duplicating film are

— image quality — legibility, resolving power, color, and contrast;

— polarity — negative- or positive-appearing;

— reproducibility;

— dimensional stability;

— quantity;

— life expectancy;

— cost;

— environmental and legal impact.

All of the sensitized materials can produce high-quality images; however, depending on the duplicator and the care taken by the operator, varying levels of image quality are achieved. Some images contain pictorial as opposed to line information. In these instances, the duplicating material must have an adequate tonal range and the user copy should be of positive polarity for the pictorial frames (negative-appearing images of pictorials do not deliver the message).

Conventional silver and vesicular print films change image polarity. Some silver materials may be reversal-processed to maintain polarity. A direct-duplicating silver film maintains polarity with conventional processing. Diazo is normally a direct-duplicating or direct-imaging material.

Except for pictorial information, either positive- or negative-appearing images may be used for viewing. The choice depends on the user, the type of reader, the need for paper prints, and the application.

If duplicates or enlarged hardcopy prints are to be made, polarity is important. Polarity of duplicate printing masters is dictated by the type of duplicating materials used and the polarity of the distribution or user copy required by the application. Because not all reader printers are bimodal, that is, capable of producing positive-appearing paper prints from positive- or negative-appearing film images, negative polarity films are necessary for the user copies from unimodal reader-printers. Some bimodal systems produce better positive paper prints from negative-appearing images.

Because diazo materials do not absorb appreciable light in the red and infrared portion of the spectrum, diazo cannot be used in some microform retrieval systems that use infrared photodetectors for image marks (blips). Some diazo films are formulated so that they can be reprinted to ultraviolet (UV)-sensitive materials. Class A films described in ANSI/NAPM IT9.5 meet this requirement.

When deciding the microfilm system requirements, the user should determine if distribution copies will be needed, and if so, how many. (See 4.4.) In a very simple system, a first-generation camera film could be used as the working copy, providing there are no requirements for keeping the master for a long retention period. If the film is used repeatedly, however, it may become scratched, broken, unreadable, and finally, perhaps, unusable.

If the system requires a number of distribution copies, the user may make one or more intermediate copies and use them as printing masters to produce the distribution copies. Distribution copies may also be made directly from the camera negative. The risk with the latter method is that during a large production run, the original may become damaged and unsuitable for further duplication.

To ensure that the header on pre-striped microfiche is right-reading, the master must be a non-striped camera original or odd-generation, non-striped intermediate master that reads right through the base side.

The quantity of duplicates to be made at one time is important. If a large number of duplicates is to be made at one time, high-volume duplicating equipment should be used. Where only one or a few duplicate microforms are required at a time, and frequently in a hurry, a small office duplicating system that requires a very simple, easy-to-operate duplicator may be desirable.

The number of distribution copies that can be produced directly from the camera negative without making an intermediate copy depends, in part, on the care taken in reproduction, the level of maintenance of the printer or duplicator, and the desired ultimate disposition of the camera negative film. Even with expendable microfilm, it may be cheaper to make an intermediate copy rather than risk damaging the original film, which can be recreated only at substantial expense, if at all.

Basic costs must include not only the expense of raw stock film stock, but the costs of equipment, materials, operators, and overhead. Silver film is the most expensive because of film and processing costs. Diazo and vesicular films are less expensive. Some diazo films require ammonia with heat and/or pressure for processing; other diazo and all vesicular films require only heat. The impact on the environment and the methods of disposing of the chemicals used in processing the various films should also be considered.

4.1 Life expectancy of copy film

User requirements for duplicate microforms can vary widely, from expendable to archival. For permanent records or archival requirements, silver films must be properly processed, handled, and stored. This entails meeting the requirements of ANSI/NAPM IT9.1. Diazo and vesicular films are used for many applications. Medium-term diazo films are suitable for a minimum of ten years, and long-term diazo films for a minimum of 100 years. These requirements for diazo films are listed in ANSI/NAPM IT9.5.

4.2 Use and durability

An important attribute of most duplicate film is durability during use. Many microforms are frequently handled; collect fingerprints, dirt, and so on; and are in and out of microform readers or subjected to scratching. Microforms intended as a permanent or archival record must be of the silver type and should not be used for reference.

4.3 Protective coatings

There are several commercially available protective coatings that can be applied to the film. The companies offering this service claim such coatings improve scratch resistance as well as pliability. The use of such treatments or coatings on film that has extended life expectancy is currently not recommended.

4.4 Quality index (QI)

The QI method permits the determination of the legibility of the final distribution microfilm image based on the height of the smallest pertinent letter or number (usually the lowercase "e") in a good contrast document that is to be microfilmed. However, it may not be necessary to capture the smallest text characters if, for example, the information they give is repetitive. The height in millimeters of the letter or number can be used with the QI Chart (figure 1) to determine the test pattern in ANSI/AIIM MS51 (ISO 3334) resolution test chart, regardless of the reduction ratio used.

The chart has three levels of quality: poor, medium, and high. The quality loss from generation to generation is also considered, and the pattern to be resolved in the camera original and subsequent generations can be determined.

The QI relies on the resolving power of the photographic system, and is, consequently, only a measure of the system's ability to record fine detail. The QI does not consider the tonal reproduction of the system and so cannot accurately measure the ability to record data that is not high-contrast black and white. It will not, for example, accurately predict the legibility of colored characters or characters on colored backgrounds.

4.4.1 Quality index (QI levels)

There are three levels of quality that can be established using the QI method. For convenience, these numeric values have been classified into three general categories of quality referred to as "High," "Medium," and "Poor." These classifications are general in nature, are based upon extensive experience in evaluating film quality, and include a subjective factor. Figure 2 is a reproduction of a photomicrograph showing levels of microimage quality defined by different values of quality index.

Poor — Images with a QI of a 3.0 or lower have very poor legibility and are generally unacceptable. Therefore, a QI of 3.6 is recommended as a (poor) minimum level of legibility.

Medium — A QI of 5.0 is considered (medium) acceptable because all alphanumeric characters can be read without difficulty on a first generation camera negative.

High — A QI of 8.0 or more is considered to be (high) excellent quality.

When microfilm is duplicated, there is typically some loss of quality. To assure that the end-user copy of a film (whatever generation that may be) is legible, the recommended QI of the original film may be raised, based upon the number of generations of film that will be produced.

4.4.2 Quality index formula

The following formula relates the pattern number on the test target that must be resolved in the image to the height of the lowercase "e", the number of generations required, and the desired Quality Index. (The formula is reduction-independent, because the pattern to be resolved expresses the required quality at any reduction.)

$$P = Q / H$$

Where:

P is the pattern number that must be resolved;

Q is the quality (poor, medium, or high);

H is the height in millimeters of the pertinent letter or number (lowercase "e") in the document to be microfilmed.

If the resolving power of the system is known, it may be substituted for P by

$$P = (\text{Resolving Power}) / (\text{Reduction Ratio})$$

In this formula, the reduction ratio to be used for a system may be calculated and adjusted to record images with suitable quality for the desired QI.

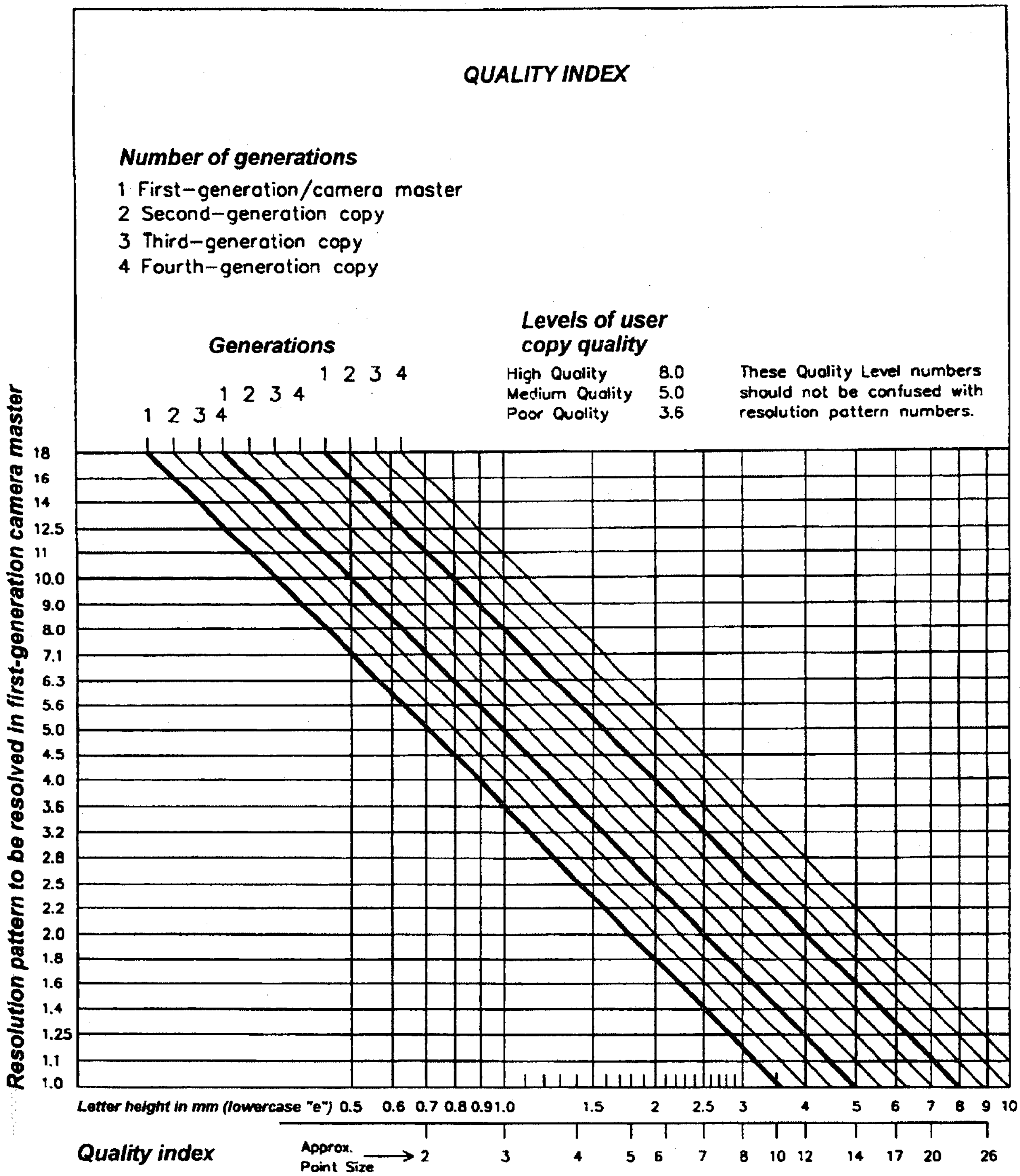
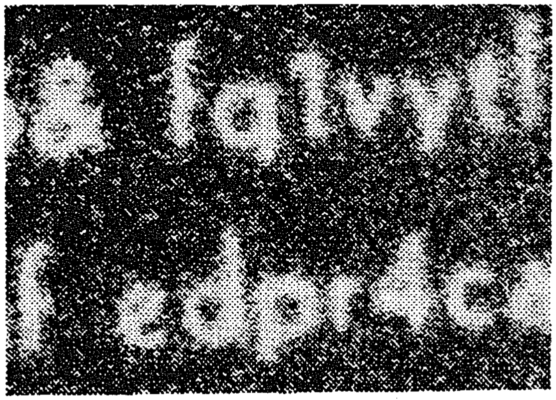
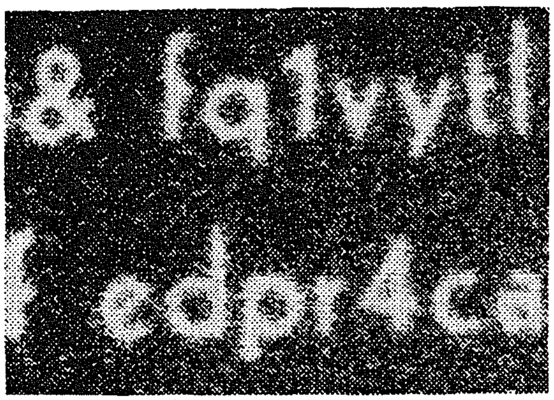


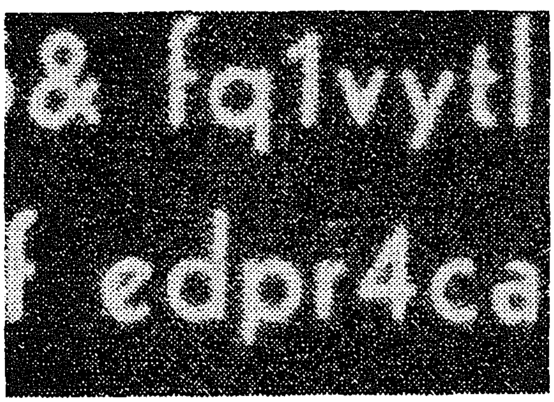
Figure 1 — Quality index chart



Poor quality (QI 3.6)



Medium quality (QI 5.0)



High quality (QI 8.0)

Note: Actual film images may differ from the above reproduction.

Figure 2 — Levels of microimage quality

4.4.3 Procedure

Step 1 — The graph shown in figure 1 is used to determine which resolution test pattern should be resolved. A measuring magnifier or eye loupe with a millimeter measuring reticle is used to determine the height of the lowercase "e" in the smallest significant printed document that is to be microfilmed. When documents of different type sizes are to be microfilmed, the smallest type size should be used for this measurement. For example, a typical type-written lowercase "e" is 2.0 mm (0.08 in) high while footnote indicators or super or subscripts may be half that size.

Step 2 — Using the graph in figure 1, move along the lower horizontal axis to find the height of the lowercase "e" as measured in the first step (in this example, the 2.0 mm point). Next, move up the vertical line corresponding with the height of the lowercase "e" to the point where it intersects with the diagonal line that corresponds to the level of user quality desired and also to the specific line in the group that corresponds to the number of generations that will be required. In this example, we wish to produce high-quality images on the third generation of copies. This means that we move up the vertical "2 mm" line from the left of the graph.

Step 3 — The intersection of the vertical and diagonal lines is on a horizontal line. Move left along this horizontal line to the left side of the graph and note the number of the resolution test pattern at the left end for the line. This number represents the pattern to be resolved in the first-generation microimage to attain a predetermined level of quality on the desired generation (copy). In the example, we would move along the twelfth line from the top to find that the 5.0 resolution test pattern would have to be resolved on the first-generation camera film to attain a high-quality image of a document with a 2 mm high lowercase "e" on a third generation duplicate.

Step 4 — These procedures may be used to determine the recording capability of your microimage production system. Film and read a resolution target (see procedures in ISO 3334), and from the acceptable recorded pattern in the left column follow the horizontal line to the right to where it intersects with the selected generation/quality line. Follow the vertical line to the letter height that can be filmed. Using this method you can establish whether your production system is capable of providing necessary quality at a given generation.

4.4.4 Limitations

The QI method applies primarily to high-quality documents. However, various document qualities should be considered. The QI makes no distinction between the following document characteristics, which can affect the overall quality of the microimage:

— dark, light or colored inks and papers;

— type fonts;

— paper reflectance or color;

— line densities, widths, and spacing.

Color, either in the printing or the background of the document, can adversely affect the legibility of the microimage. The tonal characteristics of the original microfilm should be considered because the use of lower-contrast original and duplicating films can maintain or improve legibility from generation to generation.

Documents with color should be filmed with suitable densities to achieve a quality reproduction. Actual camera and reproduction testing is recommended when unusual document characteristics are encountered. Density can also effect image sharpness because too high a density can result in the loss of fine or faint lines on subsequent generations. Too low a background density can cause bold, black lines to spread, resulting in less sharpness and poorer legibility in subsequent generations. In source document microfilming, background densities from 0.75 to 1.30 in clear-base, negative-appearing film are recommended, depending on the type of original document and on the reduction ratio. Groups 1 to 4 in table 1 indicate the density range at which these documents can be microfilmed successfully. Any of the documents may be microfilmed at a lesser density, but poor quality documents are not likely to be filmed successfully at higher densities. See table 2 for density guidelines for Computer Output Microfilm (COM).

Table 1 — Density table

Group 1	High-quality, high-contrast, printed books and periodicals; black type face; fine-line originals; black opaque pencil writing; and documents with small, high-contrast print.	Density 1.00 to 1.30
Group 2	Pencil and ink drawings; faded and very small print (for example, footnotes at the bottom of a printed page); scenic checks; documents with printed pictorial images; and newspapers.	Density 0.90 to 1.10
Group 3	Low-contrast manuscripts and drawings; graph paper with pale, fine-colored lines; letters typed with a worn ribbon; poorly printed, faint documents.	Density 0.80 to 1.00 (1:24 reduction or less)
Group 4	Very low-contrast (worst case) documents can require extremely low background density.	Density 0.75 to 0.85 (1:24 reduction or less)

4.5 Film contrast

The contrast of the microreproduction system depends on selecting the proper photographic materials for use in each generation. This dependency applies to both the exposure of the silver camera negative and subsequent printing onto the duplicating film.

The average individual who uses microfilm thinks of contrast as the magnitude of the difference in density between the light and dark areas in a microfilm image. From the user's point of view, this is a logical interpretation of contrast. However, the quality of a microfilm image depends on more than the two ends of the scale; it depends on the ability of the photographic materials to differentiate between small differences in tones in the document. The characteristic curve of the photographic film defines the contrast of the reproduction. Cascading of the characteristic curves of all films used in the system produces the system tone-reproduction curve. In a microfilm system, the contrast of this tone-reproduction curve affects the quality of the microfilm reproduction. If the contrast in the image is too high, fine lines and light lines from the original document will tend to fill in, and bold black lines from the same original will spread. Open areas in certain characters will also fill in. On the other hand, if the contrast is too low, all the graphic information will be reproduced, but the lines will appear fuzzy and the reproduction will have a flat, muddy appearance.

Film manufacturers have made camera and duplicating films with contrast designed to work together effectively. However, it is up to the user to select the proper films to use in his or her particular system.

Table 2 — Summary of acceptable density limits for COM film and duplicates

Film Type	Process	Density Measurement Method	Minimum *D*max	Maximum *D*min	Minimum Density Difference
Silver-gelatin (1P)	Conventional	Printing or visual diffuse	0.75[1]	0.15 or 0.10 plus base[2]	0.60
Silver-gelatin (1N)	Full reversal	Printing	1.5 (1.8 preferred)	0.20 plus base[1,3]	1.30
Thermally Processed Silver (1P)	Heat	Printing	1.00[1]	0.40 plus base density[2]	0.60 (0.80 preferred)
Diazo (2N)	Ammonia and/or heat	Visual diffuse	1.30	0.15 plus base density	—
Vesicular (2N)	Heat	f/4.5 projection, visual Corning 759 filter	1.8	0.15[4]	—

NOTES

1. See figure 4 for COM-generation terminology.

[1] Character or line density measured with a microdensitometer or by comparing the film under a microscope with an image of a known density.

[2] Base equals the density of the uncoated base.

[3] Character or line density measured with a microdensitometer or by comparing the film under a microscope with an image of a known density; the cut mark, which is not representative of line density, is useful in processing control only if available.

[4] Equals the density of unprocessed film that has been cleared.

5 Intermediate and distribution copies

5.1 Microfilm duplication

Microfilm duplication can be accomplished with several types of film and in a number of ways (see figure 3). The selection of specific hardware and materials with distinct properties are dictated by system requirements. Multiple copies can be made in at least the following ways:

— multiple camera exposures;

— roll-to-roll duplication;

— unitized film (aperture card, microfiche, jacket) to unitized copy (card or sheet film) duplication;

— roll-to-unitized copy (card or sheet film) duplication;

— unitized-to-roll duplication.

5.2 Microfilm duplication copies

Microfilm duplication may include the production of intermediate copies as well as distribution (release, work, reference, or use) copies. The term intermediate refers to those copies made solely to produce other film copies. The term distribution refers to those copies put in the hands of the ultimate user. The (N) and (P) are symbols for negative and positive. The number indicates the generation. For example, (2N) would indicate second-generation with negative-appearing images (see figure 3).

5.3 Duplicating films

Duplicating films are available in two types: sign maintaining and sign reversing. Conventional silver sign-reversing and vesicular films will have a polarity opposite that of the preceding generation; a negative-appearing camera film (1N) produces a positive-appearing duplicate film (2P). Thermally or conventionally processed silver COM camera films (IP) are generally used with vesicular film to produce a negative-appearing duplicate (2N). Sign-maintaining silver duplicating and diazo films maintain the polarity of the camera film; a negative-appearing camera film (IN) produces a negative-appearing direct image duplicating film (2N). Generally, low-contrast duplicating films are used for intermediate copies, and medium contrast duplicating films are used for distribution copies (see table 3).

5.3.1 Diazo films

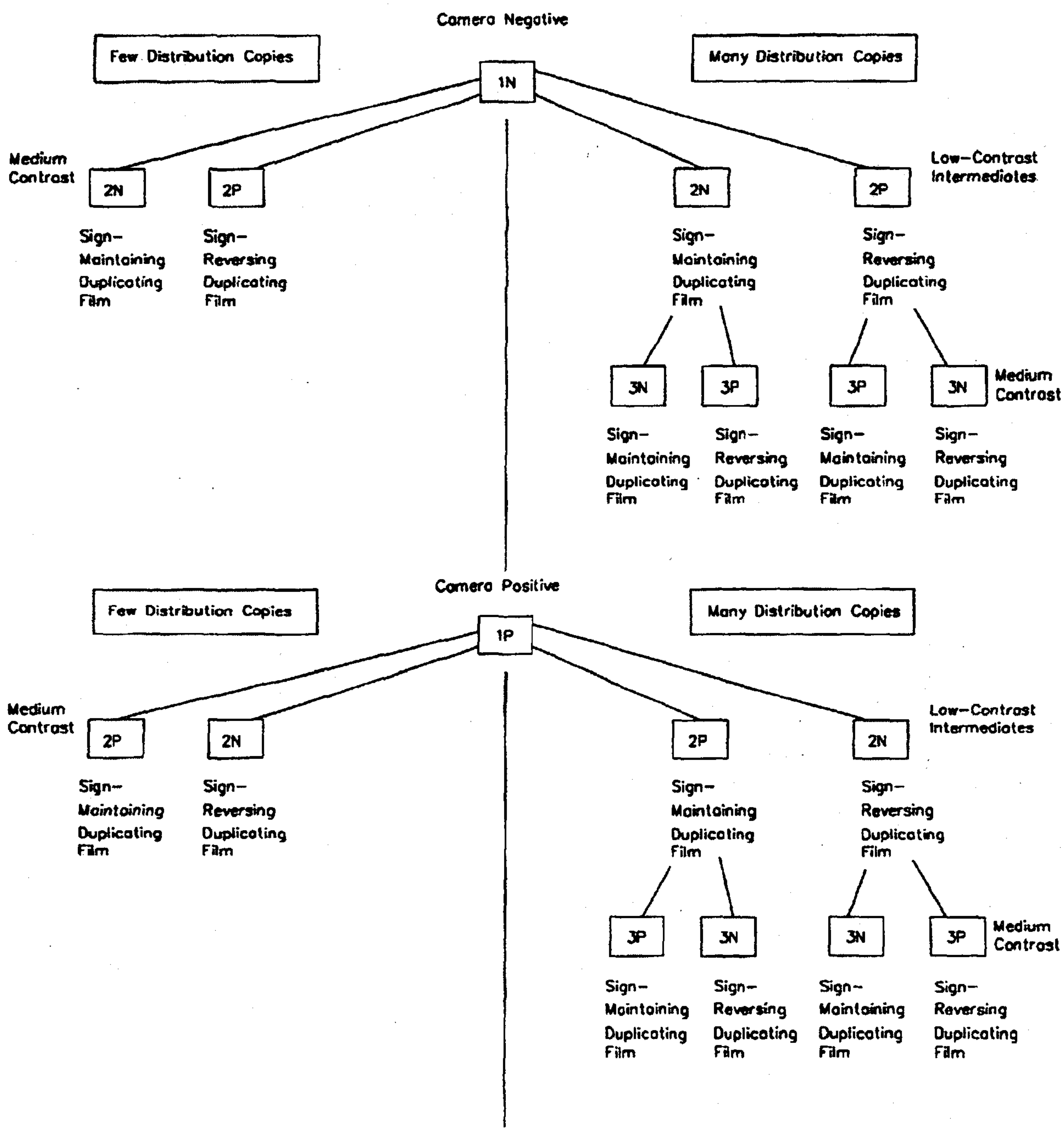
Diazo films are direct-image duplicating and maintain the polarity with respect to the camera film; a negative-appearing camera film (IN) produces a negative-appearing diazo duplicate (2N). Blue, blue/black, or black diazo films are available in medium and high contrast and medium or high speed. Reproducible low- and medium-contrast diazo can be used for printing masters or intermediate and duplication copies. Nonreproducible diazo films can be used only for distribution copies (see clause 6). Properly exposed and processed diazo films are suitable for medium- and long-term storage.

5.3.2 Vesicular films

Most vesicular films are sign reversing and change the polarity with respect to the camera film; a negative-appearing camera film (1N) produces a positive-appearing vesicular duplicate (2P). Medium to high-contrast vesicular film is used for distribution copies. Pre-exposure may be used to lower contrast in some medium contrast vesicular films (see clause 7).

The keeping qualities of properly exposed and processed vesicular films can be characterized as medium- or long-term, depending on their intended useful life. Vesicular films are classified as class A films if they meet projection and printing density requirements after their projected useful life. Class B films meet projection requirements only.

See ANSI/NAPM IT9.13.



NOTE — See figure 4 for COM flow chart.

Figure 3 — Flow chart of duplicating methods for source document films

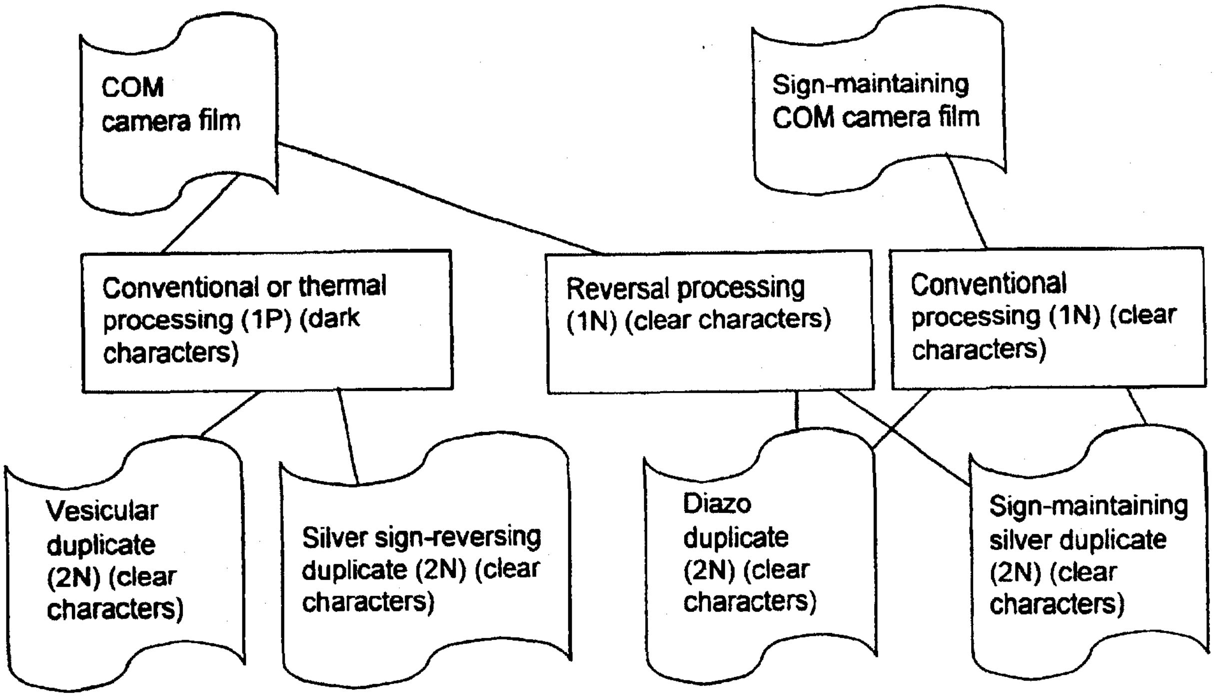


Figure 4 — COM-generation terminology

Table 3 — Comparison of duplication materials

	Film type		
Features	**Silver**	**Diazo**	**Vesicular**
Image polarity	Sign reversing or sign maintaining	Sign maintaining	Sign reversing
Film speed	Fast (0.1 mJ/cm^2)	Very slow (approx. 1000 mJ/cm^2)	Slow (20 mJ/cm^2 to 200 mJ/cm^2)
Resolution	Very high	Extremely high	High
Image formed by	Silver grains	Dye molecules	Vesicles (bubbles)
Development	Photographic chemicals	Ammonia and/or heat, pressure	Heat
Application	1) Maintains same polarity or image appearance 2) Reverses polarity or image appearance	Maintains same polarity or image appearance	Reverses polarity or image appearance
Image life[1]	1) Silver-gelatin on polyester = LE 500 2) Silver-gelatin on acetate = LE 100 3) Thermally processed silver on polyester = LE 100	LE 100	LE 100

NOTE

[1] See ANSI/NAPM IT9.1 for film stability specifications and ANSI/NAPM IT9.11 for film storage conditions.

5.3.3 Silver

Silver duplicating films are available in two types; sign-reversing and sign-maintaining duplicating. Sign-reversing films change the polarity with respect to the camera film; a negative-appearing camera film (IN) produces a positive-appearing duplicate film (2P). Sign-maintaining duplicating films maintain the polarity with respect to the camera film; a negative-appearing camera film (1N) produces a negative-appearing sign-maintaining duplicating film (2N). Generally, low-contrast sign-maintaining duplicating films are used for intermediate copies and medium contrast sign-maintaining duplicating films are used for distribution copies.

Silver sign-reversing and direct image (sign-maintaining) duplicating films can be used for permanent or extended life records when they are properly processed and stored. (See clause 8.)

6 Diazo duplication

6.1 Diazo mechanism

The diazo process is based on the ability of diazonium salts to combine with a dye coupler to form a strongly colored dye. Where exposed to ultraviolet radiation, (UV), the diazonium salts decompose, leaving an inert photolysis product and liberating nitrogen gas. The ultraviolet light is approximately 400 nm in wavelength when used for this purpose.

Before exposure and processing, the coupling process between the diazonium salt and dye coupler is prevented by an acidic stabilizer. After exposure to UV energy, the stabilizer is neutralized in an alkaline environment and coupling takes place, forming a dye image.

6.1.1 Image formation

In practice, duplication onto diazo film is a contact printing process; the emulsion of the master held in full contact with the sensitized side of the diazo film while the two films are exposed to UV light. Ultraviolet light is transmitted through clear areas of the master and blocked by the dense areas. When the transmitted UV light strikes the diazo coating, the diazonium salts are broken down to a photolysis (clear) product, no longer capable of coupling to form a dye. Nitrogen gas is emitted from the coating. Note that the plastic layer that holds the chemical products is formulated so as to permit the escape of this nitrogen.

In the unexposed area, the coating still contains the salts, the coupler(s), and the stabilizer. When the exposed diazo film is processed by an alkaline substance (e.g., ammonia), the alkali neutralizes the stabilizer. This permits the coupling process to take place, thus producing the dye image. The dye is formed in unexposed areas; that is, the areas corresponding to the dense areas of the master. The duplicate has the same polarity as the master, hence, the diazo process is a direct-image, or sign-maintaining, system.

6.1.2 Diazo development

When diazo-type material is exposed to UV radiation, sufficient energy must be provided to proportionally destroy the diazonium salts relative to the amount of exposure received. The development of the diazo film is achieved by neutralizing the stabilizer to allow formation of the dye in the unexposed and partially exposed areas.

The dye that produces the dense areas is a result of the chemical coupling of the diazonium salts and dye couplers. Full activation means that the stabilizer has been neutralized and all the salts have been coupled. Overdevelopment cannot occur. Once the stabilizer has been neutralized, the alkaline developer has no further effect on the film, and prolonged development cannot degrade the image. No amplification takes place during development, and the latent and final images are identical. Underdevelopment occurs when insufficient ammonia, heat, or time in the developer chamber prevents full dye coupling.

In microfilm systems, ammonia is generally used as the alkaline agent to neutralize the stabilizer. The speed of coupling is of great importance in the practical use of the diazo film. Heat is used in most diazo development systems because it accelerates the reaction and increases the speed of coupling.

The effect of the heat varies for different dyes and couplers, and may influence the final image color of the film. For this reason, temperature variations may cause a shift in the final image color. This color shift is most noticeable in those films that employ multiple dyes to produce the final color (e.g., black). The coupling speed of each dye is dependent on the temperature in the developer chamber. As the temperature is increased or decreased, one dye may couple faster than the other, resulting in a color shift. For this reason, temperature adjustment might be critical to achieve the desired final color. Generally, higher temperatures promote the blue dyes while lower temperatures promote the brown or sepia dyes.

There are two different methods for processing diazo film used in the microfilm industry. The vapor diazo process is the method most commonly used; the other is the thermal development.

6.1.2.1 Vapor process

The vapor diazo process has the following characteristics:

— Film coating contains the diazonium salts, dye couplers, and acid stabilizer;

— Ammonia vapor causes the development of the image; heat is used as an accelerator. One of two types of ammonia is used in the developer chamber of the diazo duplicator. Anhydrous ammonia (NH_3) is packaged under high pressure in a cylinder as a liquid and contains no water. The systems using gaseous anhydrous ammonia feed it into the developer chamber under high pressure. The high pressure further accelerates stabilizer neutralization by forcing ammonia into the coating. Anhydrous systems require a very short development time and thus are most suitable for rapid processing. Ammonia cylinders may require compliance with federal, state, and local codes.

Aqueous ammonia (NH_4OH) is ammonia in a water solution (ammonium hydroxide), where the water is used as a medium or carrier and helps the ammonia to penetrate the sensitized layer. Aqueous ammonia is less active than high-pressure anhydrous ammonia. The aqueous ammonia solution is heated and generally reaches the film as a vapor. In some cases, anhydrous ammonia is fed into the development chamber, where it is mixed with water vapor at low pressure. This is commonly referred to as an aqueous development system.

The type of ammonia system employed affects the rate of coupling of the diazo salt and coupler. The color of the diazo film may differ when processed in one or the other of these systems even though the developer temperature is held constant.

6.1.2.2 Thermal development

Thermal diazo film differs from conventional diazo products in that ammonia is not used for development; heat is the developing agent. In the one product commercially available, heat causes migration of the salts and couplers to form the dye image.

6.2 Diazo film structure

Diazo films consist of a photosensitive layer coated on polyester base treated for adherence. The photosensitive layer consists of diazonium salts, acid stabilizer, and coupling compounds.

6.3 Sensitometric properties of diazo film

It has been stated in 6.1.2 that diazo film cannot be overdeveloped and does not involve any amplification process. The sensitometric characteristics of a given film depend almost entirely on the actual formulation of the diazo coating. This situation is very different from the case of silver emulsions, where the shape of the characteristic curve can be modified by processing conditions. This characteristic makes diazo film a very simple and reliable duplicating medium.

6.3.1 Spectral sensitivity

Because the diazo process does not include energy amplification, powerful light sources rich in violet/ultraviolet radiation must be used for exposing the diazo coating (decomposing the diazonium salts). High-pressure mercury lamps are most suitable for this purpose, and the light emission is well matched to the spectral sensitivity of the diazo coating. This means that diazo films have limited sensitivity to visible light — thus are less effected in short-term exposure to room lighting conditions. However, even this exposure should be kept to a minimum. Ultraviolet components of a room light source (fluorescent lamps) or sunlight will have an adverse effect on the film by decomposing the diazonium salts and fogging it. The extent to which this occurs depends on the strength of the ultraviolet component and the time that the film is left exposed.

6.3.2 Speed

Sensitometrically, the speed of a diazo film is measured by the exposure (intensity × time of exposure) required to destroy the diazonium salts in the coating. The final image is defined at the time of exposure. A master with high minimum density (*D*min) significantly reduces the copying speed of diazo film by blocking the light energy in the low-density areas. This film requires more time to properly expose the diazonium salts.

Other points of interest regarding the speed of diazo film follow:

— Black film is generally slower than blue film because of multiple dyes;

— The higher is the maximum density (*D*max) capability of the film, the slower is the film speed, and vice versa.

6.3.3 Resolution

The image on a diazo film is made visible as a result of the dye formed within the coating. The dye results from the coupling of the diazonium salts and dye coupler. The coupling takes place at a molecular level. Resolution is dependent on "grain size" (in this case, a molecule); and, hence, diazo films have extremely high resolution capabilities that have been determined to be in excess of 1000 lp/mm.

Diazo film is a very suitable duplicating medium, but the high value of resolution will not necessarily produce a copy of high quality. Rather, the quality of the master will determine, in large part, the quality of the final copy. The duplicator itself plays a role, in that some duplicators, because of either poor contact or poor collimation of the light source, can adversely affect resolution. Most microfilm systems operate in the region of 50 lp/mm to 200 lp/mm.

6.3.4 Contrast

Diazo films are classified as medium to high contrast. The characteristic curves seldom have a straight line portion, and bar gamma ($\bar{\gamma}$) is most frequently used to technically describe the contrast of the film. A high-contrast film has a $\bar{\gamma}$ of 1.5 or above, whereas a medium-contrast film has a $\bar{\gamma}$ of less than 1.5.

6.3.5 Diazo image color

As mentioned previously, the diazonium salts react with the couplers in the coating to form a colored dye. A dye has a certain color because it transmits light of that color (wavelength) and absorbs (blocks) the other colors. The colors absorbed or transmitted by diazo film can be determined from the spectral density curve available from most manufacturers.

In the manufacture of diazo films, the following points are considered:

a) The final color of the dye is dependent on the choice of diazonium salt and coupler. It is possible to produce yellow, red, sepia, and blue diazo films using a single dye.

b) Black films are most complex and require a combination of dyes that will absorb the light source and give the appearance of a black image. The development process is more critical to obtain a neutral black. Color shift may result from a change in development temperature or a change in processing system.

c) Resistance to fade and the speed of coupling are strongly affected by the choice of salt and coupler.

When the film is viewed on a reader, the sensitivity of the human eye is the determining factor. The eye is most sensitive in the yellow/green areas; hence either blue or black diazo will appear to have excellent contrast.

6.3.6 Reproduction characteristics

Reproduction characteristics are important where the diazo film will be used as a master to make paper copies on a printer or to make additional diazo copies.

Because diazo film transmits some colors and blocks others, it is necessary to consider the following reproduction characteristics: (1) the spectral characteristics of the reproduction system (that is, the exposing light source, the spectral absorption of the intermediate, and the unexposed diazo film sensitivity), and (2) the spectral absorption of the diazo film used as the master (that is, its ability to block the wavelengths in the sensitive region of the duplicating materials). Spectral sensitivity is normally in the violet and ultraviolet regions. The density in this region is called "print density" and must be measured with a densitometer that matches the spectral sensitivity of the diazo film. Microfilm printers differ widely in their spectral characteristics. The film manufacturer should be consulted and a diazo film selected that best matches the spectral characteristics of the printer. For contact printing, the diazo master must block the ultraviolet radiation.

6.4 Shelf life and storage of unexposed film

The shelf life of diazo film is limited. After a period of time specified by the manufacturer, the stabilizer in the sensitized layer becomes neutralized and precoupling of the dye may occur before exposure. This is typically exhibited by coloration at the film edges.

The film is generally warranted for six months at 24 °C (75 °F) and this can be extended to one year at 16 °C (60 °F) and eighteen months at 7 °C (45 °F). Unexposed diazo film cannot be harmed by x-ray or infrared radiation provided the film temperature never exceeds 24 °C (75 °F). The film must be stored away from any ammonia or alkaline fumes to prevent premature development of the coating. The best storage conditions are 7 °C (45 °F) to 21 °C (70 °F) and 40 % to 60 % relative humidity.

6.5 Working conditions

6.5.1 Lighting requirements for unexposed diazo film

One of the major advantages offered by diazo film is that it can be used and handled under room light conditions. The following precautions are necessary:

— Sunlight (daylight) and white fluorescent light contain a fair amount of UV. Diazo films must be protected from exposure to direct sunlight and daylight; exposure to incandescent and white fluorescent light should be limited;

— Yellow fluorescent or low-intensity incandescent lights are recommended for use. Yellow filters can help block out UV radiation;

— Whenever possible, the film should be kept in its protective wrapper.

In practice, the film should always be properly protected to avoid unnecessary risk.

6.6 Storage and stability of processed film

In general, diazo film is more scratch resistant than silver or vesicular films. When left in readers or in direct sunlight for extended periods, the visual dye image will begin to fade.

Some diazo dyes are stable and suitable for long-term storage (over 100 years), provided the film meets the required conditions of ANSI/NAPM IT9.5 and ANSI/NAPM IT9.11. (See 4.2.)

Some variables that should be considered are temperature, humidity, enclosures, ventilation, and fire protection. It is recommended that diazo film not be stored or interfiled with other microfilms.

6.7 Choosing a diazo film

The choice of diazo film type is most important if satisfactory results are to be achieved. When selecting a diazo film, the manufacturer's specifications should be studied to ensure that the film characteristics match those required.

The choice of duplicating film depends on the image quality of the master film. The most important criteria are character/background characteristics of the master; and these determine the choice between a high- or medium-contrast film. COM master images are usually high contrast.

Several characteristics of diazo film are relevant when making a choice; some are interdependent. See table 4.

6.7.1 Contrast

Diazo films are classified as high or medium contrast. A typical high-contrast film will have a bar gamma ($\bar{\gamma}$) equal to or greater than 1.5 and a medium contrast film will have a bar gamma of less than 1.5.

Table 4 — Diazo film characteristics

Characteristics	Options
Contrast	High or medium
Color	Blue, black, blue/black, or sepia (brown)
Throughput speed	Low or high
Life expectancy	LE 100 or LE 10
Color title striping	Yes or no
Autogeneration[1] capability	Yes or no

NOTE

[1] Autogeneration is the process by which an image is duplicated on a product of the same kind. It is commonly used in the duplication of diazo film.

6.7.2 Color

The selection of the color of the diazo-duplicate stock will depend on the following:

Blue film is generally easier to use in production because the color is consistent and a blue dye film offers higher throughput speeds. Blue film is generally used for a read-only copy.

Black film is generally used where high-quality reprints (on a reader-printer or autogeneration) are required. However, some blue films also offer good reader-printer reprint characteristics, and should be considered. Micropublishers, traditionally users of silver film, often prefer black because of its appearance. Sepia film is normally used for autogeneration.

6.7.3 Throughput speed

In some installations or applications, throughput is of the utmost importance. In such cases, the diazo film speed may be the most significant factor.It is generally true to say that (1) medium-contrast films are faster than high-contrast films and (2) blue films are faster than black films, and throughput can be affected accordingly.

The foregoing are guidelines only. The choice must be based on the application under consideration.

7 Vesicular duplication

7.1 Vesicular mechanism

A vesicular coating contains diazonium salts in a plastic layer (polymer). When exposed to ultraviolet radiation, the diazonium salts in the coating decompose, forming nitrogen and a colorless photolysis product. This constitutes the latent image.

The latent image is developed by subjecting it to heat. The plastic layer is momentarily softened, allowing the trapped nitrogen to expand and form microscopic vesicles (bubbles) that become stable when the film cools. These vesicles create the image by scattering light when projected on a screen.

After the original image is formed, the film must be fixed by re-exposure to UV to form a stable image. Fixing ensures that all residual active salts are decomposed.

7.1.1 Image formation

Duplication onto vesicular film is a contact process where the emulsion of the master is held firmly against the vesicular coating. Ultraviolet light passes through the clear areas of the master and strikes the vesicular film, forming a latent image.

The nitrogen gas liberated on exposure immediately begins to diffuse from the emulsion, thus lowering *D*max. This lowering is known as latent image decay. To minimize the effect of this diffusion on background density, the time between exposure and development should be minimized. If the vesicular film is developed within 30 s of exposure, this effect will be minimal. High temperatures [approximately 49 °C (120 °F)] at the film plane during exposure should be avoided, because they will cause premature development of the vesicular image.

7.1.2 Thermal development

The latent image in the coating is developed by heat. In practice, this means that the image layer must be subjected to a temperature between 107 °C and 143 °C (225 °F and 290 °F) for approximately 1/2 s to 1 s. The heat softens the polymer, permitting the nitrogen to form vesicles. At this temperature the vesicles grow to a size of approximately 1 micron (µm) in diameter. When the film cools (usually immediately following development), the vesicles become stable. Full development of the film according to the manufacturer's recommendations is important to ensure usable quality and stable images.

Film that is inadequately developed has a vesicle size of less than 0.5 micron (μm). Fortunately, such film can easily be detected. When held up to a white fluorescent light, the image areas appear to be sepia-toned (brownish). This film does not possess stability equal to that of fully developed film. The image could fade after a short time if subjected to excessive heat.

7.1.3 Fixing the vesicular image

After development, the coating contains a fully developed image but still has photosensitive salts dispersed in those areas that were not struck by UV light. The film is fixed by overall re-exposure to UV. All previously unexposed diazonium salts are decomposed to stabilize the film. Thus, no photosensitive compounds remain in the film. Diffusion of the nitrogen from the polymer layer starts immediately on re-exposure; however, fixing is complete only when all the nitrogen has escaped from the film. The film must be left for approximately 3 h at a temperature below 75 °C (167 °F) to allow complete diffusion. Excessive heat might cause the development of vesicles in unwanted areas, or might cause blistering.

7.2 The vesicular image

Commercially available vesicular duplicating systems change polarity. Negative-appearing images produce positive-appearing duplicates. Positive-appearing images become negative-appearing when duplicated onto vesicular film. (Polarity-maintaining vesicular films are available.)

When light is transmitted through processed vesicular film, the clear areas allow the light to pass through, while the image areas (containing the vesicles) scatter the light in all directions. The viewing conditions are important, because density depends mainly on the light-scattering effect of the vesicles rather than their absorption. When viewed with the unaided eye, the microimages are unsatisfactory and have insufficient contrast. The effective contrast and density of a vesicular image depends on the viewing or projection aperture of the microform reader. Ideally, the measurement of density should be made with a densitometer in the projection mode having the same numerical aperture in its projection optics as the microform reader in which the film is intended to be viewed. Because an f/4.5 lens aperture was commonly used in microform readers when vesicular film was initially marketed, a f/4.5 aperture was used as a *de facto* standard for quality control in projection/densitometers. Although newer readers use lenses with large apertures, the large amount of existing data resulted in the continued use of an f/4.5 aperture in projection densitometers.

When the vesicular image is viewed directly with reflected light, it may appear to be raised or in relief. This is due to the "swelling" of the polymer where the bubbles have been formed. The reflected image polarity is the opposite of the transmitted image polarity.

7.3 Sensitometric properties of vesicular film

7.3.1 Spectral sensitivity

The diazonium salts in the vesicular coating are most sensitive to UV. High-pressure mercury lamps are most suitable for use in vesicular duplication processes.

7.3.2 Speed

For comparative speeds, see table 3.

7.3.3 Resolution

Vesicular films are capable of resolving upwards of 400 lp/mm. Present commercial films have a resolving power in the range of 300 lp/mm to 325 lp/mm. Most microfilm systems operate in the region of 50 lp/mm to 200 lp/mm. This resolution is adequate for microfilm applications.

7.3.4 Exposure latitude

Vesicular films have poor exposure latitude; and as a result, excessively high- or low-density images or images with variable density over the frame are very difficult to duplicate satisfactorily. This is noticed mostly during duplication of variable-quality source documents.

7.3.5 Contrast

7.3.5.1 General

Vesicular films with different contrasts for different applications are available. COM and high-quality, high-contrast source document films can be duplicated on high-contrast vesicular film. Most source documents should use medium-contrast vesicular films.

7.3.5.2 Pre-exposure and its effects

Pre-exposure is a technique used to lower the contrast of vesicular film and must occur immediately before exposure. When used effectively, the pre-exposure is adjusted to the maximum level that will not cause any fogging of the film. Pre-exposure is useful when duplicating continuous-tone source document images and can often enhance areas of weak imagery.

7.3.6 Reproduction characteristics

The fact that vesicular image contrast varies with relative lens aperture is of significance when considering printing characteristics.

7.3.6.1 Projection printing to hard copy

Vesicular density measurements should be made using a projection densitometer with an f/4.5 aperture. If the relative aperture in the enlarger-printer or reader-printer is larger (e.g., f/2.8), the viewed image and hard copy will have reduced contrast.

7.3.6.2 Contact printing

When vesicular film is used as a master to duplicate to vesicular or diazo films, the UV diffuse density of the film must be considered. The Wratten 18A filter together with an infrared rejection filter may be used to measure this density. (See also the alternate narrow-band method described in ANSI/ISO 5-3.) This density is much lower than the projection density because of light scattering. As a result, vesicular films ordinarily have poor contact printing characteristics. However, if UV-absorbing dyes (yellow) are incorporated into the film, the autogeneration characteristics can be vastly improved, and the film can be expected to produce high-quality copies. Contact printing of vesicular film to silver film will result in low contrast and is not recommended.

7.4 Shelf life and storage of unexposed film

The shelf life of vesicular film is virtually unlimited. The photographic characteristics of the film remain unchanged provided the film is stored in a cool, dry place. The individual manufacturer's recommendations for storage should be followed closely.

7.5 Working conditions

7.5.1 Lighting requirements for unexposed vesicular film

The relative insensitivity to visible light allows vesicular film to be handled under normal room light, eliminating the need for a darkroom. However, the following considerations should be noted:

- — Sunlight (daylight) and white fluorescent light contain a fair amount of UV. Vesicular films must be protected from exposure to direct sunlight and daylight; exposure to incandescent and white fluorescent light should be limited;
- — Whenever possible, the film should be kept in its protective wrapper.

7.6 Storage, handling, and stability of processed film

Vesicular film should not be interfiled or stored with other microfilms. The following statements concerning the stability of the film under various conditions are relevant. See ANSI/NAPM IT9.11 and ANSI/NAPM IT9.13.

7.6.1 Handling

Localized high pressure can collapse the bubbles and may degrade the image on processed film.

7.6.2 Thermal stability

The temperature at which the polymer softens (known as the glass transition temperature) is about 65.5 °C to 93.3 °C (150 °F to 200 °F) and varies for different films and manufacturers. At or above this temperature, movement or "flow" of the polymer takes place, leading to a collapse of image bubbles. The film should therefore be protected from elevated temperatures. As a practical matter, temperatures above 65 °C (149 °F) should be avoided for extended periods. If a microform reader that conforms to

ANSI/AIIM MS20 is used, MS20 states that the temperatures of the silver film at the film gate shall not exceed 75 °C (167 °F). Because the vesicular image scatters the light energy instead of absorbing it, the vesicular film temperature is lower than 65 °C (149 °F), and the thermal stability of the vesicular film will not be impaired.

7.6.3 Chemical stability

Once the vesicular film is properly exposed and processed, materials within the film itself do not interact with each other, the polymer, or the film base. The polymer is resistant to most chemical substances and so offers a high degree of stability.

7.6.4 Effects of temperature

Increased levels of humidity combined with heat have the effect of lowering the glass transition temperature of the polymer. In practice, the combination of temperature and humidity at which any fading of image density can be detected is well above the combination that is experienced even under the most adverse storage conditions.

7.6.5 Effects of ultraviolet and infrared radiation

The projected image is unaffected by exposure to UV rays although the image enhancement dyes may change color. Vesicular images are unaffected by infrared (IR) provided the coating temperature is not raised above 65 °C (149 °F).

8 Silver duplication

8.1 Silver mechanism

Silver-halide duplicating films are available in two types: sign reversing and sign maintaining. Conventional sign-reversing films reverse the polarity of the master; a negative-appearing master (1N) produces a positive-appearing duplicate film (2P). Direct image (sign-maintaining) duplicating films maintain the polarity of the camera film: a negative-appearing master (1N) produces a negative-appearing direct-image duplicate (2N).

Silver-halide films contain light sensitive silver-halide grains suspended in a water permeable binder, typically gelatin made from animal bones or hides. When light strikes the film, the silver-halide grains absorb the photons freeing up electrons, which combine with silver ions to form silver nuclei, called "latent image" in sign-reversing films. In sign-maintaining films the silver-halide grains are prefogged, and when struck by light the prefogged silver centers are bleached off leaving the prefogged grains in the unexposed areas. Subsequent development converts grains with latent image or prefogged grains to image forming silver density by increasing the number of silver atoms in each grain. This is followed by fixation, which removes the undeveloped silver halide grains. This development process is called image amplification because the original image exposed by light is not visible to the human eye but is after development.

8.1.1 Image formation — Sign reversing

When light strikes the emulsion in sufficient quantities, a change takes place in the emulsion, causing small parts of the silver-halide crystals to be converted to silver nuclei. No silver nuclei will be produced in places where no light (or too little light) has fallen, so the silver-halide emulsion there remains unchanged. A complete but still invisible image (latent image) is formed in the emulsion during proper exposure. When the film is developed, the latent image is converted into a visible image by the chemical action of the developer. Those silver-halide nuclei, which carry the latent image, are converted to metallic silver. A fully developed emulsion contains silver grains where light was received, while the original unaffected silver-halide crystals are in those areas not illuminated by light.

After development, the film is chemically fixed. The action of the fixer is to dissolve and render water-soluble the remaining undeveloped silver-halide crystals, leaving only the developed silver on the film. After fixing, the film must be thoroughly washed to remove all the remaining chemicals. As a result of conventional processing, a visible image is created in those areas affected by light, while the unexposed areas appear clear.

8.1.2 Image formation — Sign maintaining

Direct-image duplicating films produce copies with the same image polarity as the original microfilm. An advantage of silver films is the amplification of the effects of exposure during development. It takes less exposure to create an image on silver film than on other duplicating films. Typically when light strikes the silver film emulsion in sufficient quantities, the pre-fogged silver is "bleached" off, thus rendering that area of the film undevelopable.

8.1.3 Processing

Current commercially available silver duplicating films are designed for conventional processing. This consists of the following steps: (1) development, (2) fixing, (3) washing, and (4) drying.

8.1.3.1 Development

The developer solution is a complex formulation whose primary function is to chemically reduce light-exposed or chemically fogged silver-halide crystals to metallic silver images. Ideally, only the desired silver-halide grains are developed. If development conditions (time, temperature, agitation, chemical concentration, and composition) as specified by the manufacturer are not controlled, development of unexposed silver halide can take place in sign-reversing films.

This phenomenon is known as fogging (undesirable) and occurs when the developer or developer conditions are overactive. In practice, base-plus-fog density must be closely monitored to ensure that this will not happen. It is important that the developer act selectively, that is, to chemically reduce the desired silver halide containing latent images to silver while having little or no effect on the other grains expected to remain undeveloped. This selectivity is carefully determined in the design of film and processing chemicals for given processing conditions. Any change in such conditions may cause the developer to operate outside these limits.

8.1.3.2 Fixing

After passing through the developer, the emulsion now contains

- metallic silver in those areas affected by light;
- silver halide that is unexposed and still light sensitive.

The function of the fixer is to render the silver halides soluble by chemical action and turn them into neutral salts. Once these salts are completely dissolved in the fixer, only the clear-appearing gelatin is left in the unexposed areas. The requirements of the fixer are

- to dissolve silver halides without affecting the metallic silver image;
- to be stable in solution and not produce solid by-products.

The most frequently used fixing agent used in the microfilm industry is ammonium thiosulfate. The efficiency of the fixing process for a given film is dependent on fixing time, temperature, agitation, and concentration. Manufacturer's recommendations should be followed.

8.1.3.3 Washing

Washing removes the soluble chemical compounds and fixer from the emulsion. Excessive fixer, if left in the emulsion, may result in loss of image density. Adequate washing is of great importance, and tests have been designed to measure the amount of fixer remaining in the film after processing. See ANSI/NAPM IT9.17. If archival processing is required, also see ANSI/NAPM IT9.1. Efficiency of washing depends on time, water temperature, acidity or alkalinity (pH), and rate of water change. The washing of the film is less effective if the fixer contains a high concentration of silver. Temperatures should be compatible with other processing solutions. The user should check the local water quality for hardness, pH, and impurities. Very hard water may need to be treated before being used. Excessively soft water may lead to reticulation and/or abrasion of the film. The suggested limits on water hardness are 16 parts per million or mg/l to 150 parts per million or mg/l (0.9 grains per U.S. gallon to 8.8 grains per U.S. gallon) of calcium carbonate ($CaCO_3$). Suggested pH should range from 7 to 8.5. Filters may be required to keep impurities out of the photographic processor.

A hypo clearing bath that contains sulfite is permissible as a washing aid if processing to archival specifications is required. Hypo eliminators, which contain oxidizing agents such as peroxide, are not permitted. Oxidizing agents not only interfere with archival testing but may promote image deterioration.

8.1.3.4 Drying

Normal drying temperatures vary between 43 °C to 71 °C (110 °F to 160 °F) at a relative humidity of less than 80 %. Film and equipment manufacturer's recommendations should be followed with regard to drying. The following precautions apply mainly to large processors.

The user may want to install air filters to make certain that the air used is clean and does not contain dirt from the surrounding environment. While adequate drying is necessary to prevent the film from sticking together in the roll, care should be taken not to overdry the film. Drying time depends on the relative humidity, circulation, and temperature of the air and on the type of film being used. Drying cabinets may require static eliminators to prevent the buildup of static electric charges on the film, which attract dirt and dust particles.

8.1.3.5 Process control

Processors should be monitored regularly in order to ensure consistent quality. This is done with sensitometric control strips. These film strips contain precision levels of exposure that, when processed, will yield a series of measurable density areas ranging from clear to black. These strips may be produced by the user or may be purchased from many film manufacturers. For best control, it is recommended that the film used for the control strips be of the same type as used in production. They should be used at the start of processing each day, after changing chemicals, and three or four times a day if a high volume of film is being processed. It is recommended that the density values of the control strips be plotted on a chart (see figure 5).

8.2 Sensitometric properties of silver film

8.2.1 Spectral sensitivity

Silver emulsions respond differently to the various colors of the visible spectrum (400 nm to 700 nm). Silver duplicating films are typically orthochromatic, sensitive to blue and green light (400 nm to 600 nm) or extended blue. Optimum printing efficiency can be achieved by matching the spectral output of the exposing light source with the film.

8.2.2 Speed

Silver duplicating microfilms are considered slow speed for silver films but are very fast relative to diazo and vesicular duplicating films. (See table 3.)

8.2.3 Resolution

Resolving power or resolution of any film should be used only as a basis for comparing films. Silver duplicating films are available that are capable of resolving up to 1000 lp/mm.

8.2.4 Contrast

Generally, low-contrast duplicating films are used for intermediate copies, and medium-contrast duplicating films are used for distribution copies.

8.3 Working conditions

Unprocessed silver duplicating films are daylight sensitive and therefore must be handled under darkroom conditions. The film manufacturer will specify safe light conditions.

8.4 Shelf life and storage of unexposed film

The shelf life of unopened silver duplicating films is up to 2.5 years if properly stored at 13 °C (55 °F) and 50 % relative humidity or below, and protected from radiation and x-rays. Individual manufacturer's recommendations for storage should be followed closely.

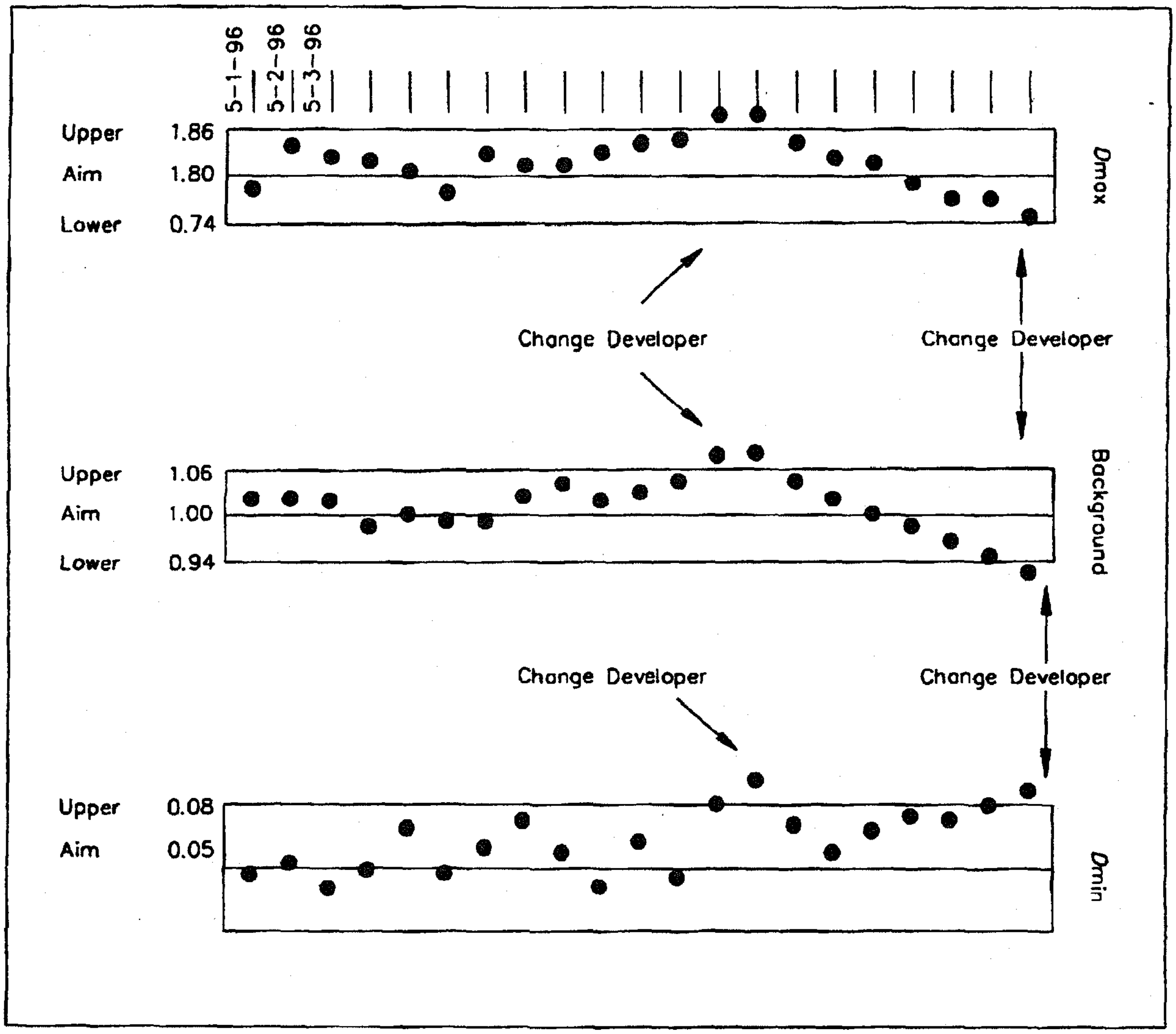


Figure 5 — Example of processor control chart

8.5 Permanent and extended life storage and stability of processed silver duplicating films

Silver films are required for permanent and extended life records. Silver duplicates may be used for this purpose, but they must be processed and stored properly. Specifications for long-term storage of silver films are provided in ANSI/NAPM IT9.11. It is recommended that silver films not be stored with diazo or vesicular films. The gelatin layer of silver duplicating films can be susceptible to damage by abrasion. If accidental exposure to moisture occurs, be sure that the film is dry before rewinding or refiling. Such damage can distort or destroy information recorded on processed film.

8.6 Silver recovery

When practical, adding a silver recovery unit to the processor is recommended, particularly when conventional processing to yield a positive-appearing image is used. A silver recovery unit may be useful for two reasons. First, if a large quantity of film is processed, recovering silver from the fixing bath can yield a source of income that may more than pay for the cost of the silver recovery unit and the associated labor costs over a period of time. Second, with the ever-increasing environmental restrictions regarding disposal of photographic chemicals, particularly such substances as silver, it may be necessary to reduce the silver concentration to an acceptable level before discharging the effluent into a sanitary sewer.

9 Microform duplicators

9.1 General

Roll film and microfiche duplicates may be created in many ways, primarily depending on how the duplicate will be used and how many copies are required. Most film duplicators are contact printers, either stationary or continuous. During exposure, conventional contact printers bring the processed image surface of the printing or intermediate master into direct contact with the unexposed sensitized layer of the next-generation film. A projection printer projects the image of the illuminated master or intermediate onto the sensitized layer of the next-generation film at a predetermined ratio (1:1, 1:2, etc.). A stationary-type printer, whether contact or projection, allows neither the input nor output films to move during exposure. A roll-to-roll film contact duplicator has both films in close contact and in continuous motion. The relative motion between the two films is minimal, because both films are moving in the same direction at the same speed.

A rise in image contrast, a reduction in quality index (resolution), and a change in density can normally be expected with each generation. (See 4.4 for QI losses.) When there are wide density variations among strips or rolls of film that will be duplicated at one time, some provision must be made to change the exposure setting during the duplicating operation. Some duplicators have accessories for selecting the proper exposure for each strip or roll.

9.2 Stationary contact duplicators

Stationary contact printers are most prevalent in microfiche duplication. A contact duplicate may be made from a conventionally or thermally processed silver master, nonsilver master, or intermediate onto either silver, diazo, or vesicular duplicate films. Stationary type of contact printing is used for unitized-to-unitized, roll-to-unitized, unitized-to-roll duplication.

9.2.1 Manual unitized-to-unitized duplicators

These include the many small one or two-step duplicators used for microfiche, copy card, and jacket duplication. The two-step process is normally used for on-demand, low-volume vesicular or diazo duplication. The printer uses either a platen or a moving drum for the ultraviolet exposure. The separate processor generally uses heated rollers for vesicular, either gaseous or aqueous ammonia and heat for diazo and heat for thermally processed diazo. Duplicating through jackets may cause a loss of more than one pattern on the resolution test chart per generation. (See ANSI/AIIM MS11.)

9.2.2 Unitized-to-unitized duplicators

Medium- and high-volume microfiche-to-microfiche duplicators use either roll diazo or vesicular film, which is automatically exposed, processed, cut, and stacked by the duplicator. Collator/separators are used in line with these duplicators to provide ready-to-distribute or mail microfiche. These systems are used for medium- or high-volume COM or source document microfiche distribution.

9.2.3 Roll-to-unitized duplicators

These provide vesicular or diazo duplication from 105 mm rolls of microfiche generated by COM or with step-and-repeat cameras. These medium- and high-volume duplicators use roll diazo or vesicular film that is automatically exposed, processed, cut, and stacked by the duplicator. These duplicators expose the camera or COM roll master in sequence, or according to a program input by the operator, or from a document mark code on the microfiche.

9.2.4 Unitized-to-roll duplicators

Medium and high-volume unitized-to-roll duplicators use either roll diazo, silver, or vesicular films. Diazo and vesicular films are automatically exposed, processed, and taken up in roll form. Silver film is automatically exposed and rewound in a light-tight container. This silver film is then wet-processed in a separate processor.

9.3 Roll-to-roll microfilm duplicators

Roll-to-roll microfilm duplicators are used for 16 mm, 35 mm, and 105 mm roll-to-roll duplication to silver, diazo, and vesicular films. Diazo and vesicular films are exposed and processed in one device. Silver film is exposed and processed in two separate steps under safelight conditions. When a number of copies are required from a single roll, the roll master or intermediate is frequently made into an endless loop and duplicated loop to roll. Some roll-to-roll duplicators are available with a loop accessory.

A roll-to-roll duplicator should track correctly; otherwise, document marks, if any, may not line up correctly for retrieval in the reader, or images may be clipped off or duplicated into the edge of the film. The tension in continuous roll-to-roll contact duplicators must be correctly balanced or film slippage may occur. Good contact must be maintained between the processed image surface of the master or intermediate film and the sensitized side of the duplicating film. Newton rings may detract from the appearance of the microfilm, but they are an indication that maximum practical contact has been achieved. With properly adjusted duplicators, loss of less than one pattern on a resolution test chart per generation of duplication should be expected. In checking a continuous roll-to-roll 16 mm duplicator, it may be convenient to use SMPTE Test Film 16RT. See annex B. Silver duplicate films should be inspected for variations in density along the length and width of the film. The proper controls should ensure uniform illumination in the exposures plane to provide uniform density along the length and width of the film.

9.4 Projection duplication

Project duplication is used to change the format, further reduce the image size, or both. For example, projection duplication can be used to create a higher-reduction-ratio microfiche master from a lower-reduction-ratio roll film. Another application is to reduce 35 mm master rolls onto 16 mm film for intermediate or distribution copies. These are specialized applications, and only a few microfilm service companies have the projection duplicators required for conversion.

9.5 Duplication control

When printers or duplicators are being used to produce duplicate 16 mm or 35 mm films, microfiche, or copy cards, it is advantageous to duplicate a density control target on a daily basis and record the information. It is also helpful to run a resolution test chart on a daily basis and record the information. This test brings attention to a problem before a large quantity of duplicates is prepared. If the test density changes from normal conditions, then corrective action should be taken (see figure 6 and annex A). If the resolution drops more than one test pattern per generation, corrective action should be taken.

10 Diazo control

10.1 Diazo exposure control

The optimum exposure setting for duplicating source document images on diazo film is the exposure that reduces the line density of a negative master to a minimum density of 0.05. Overexposure should be avoided, because reduced contrast and loss of resolution may result from excessive "burning-out" of the background density. For most practical purposes, an acceptable image can be obtained by duplicating a 0.35 density of a step tablet or areas of the negative master to a 0.35 visual density on the diazo duplicate.

In practice, very few images have a single line density value that is representative of all densities. The problem is further complicated by the need to duplicate a series of images of varying density (such as those found in a roll or microfiche) at a single exposure setting. By setting the exposure to accommodate the worst case (i.e., highest density lines in the case of a negative master), an optimum overall quality duplicate will result.

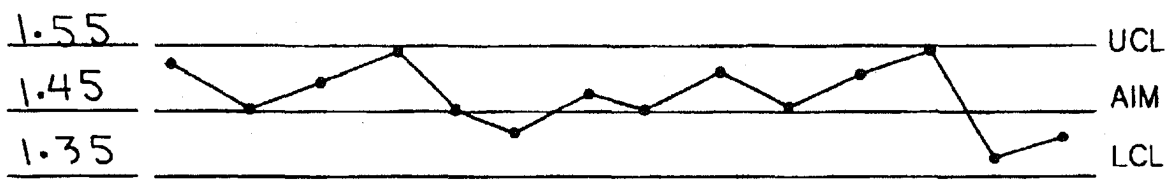
The image quality of distribution copies must be judged by comparing the information fidelity to the original. Then the minimum density (Dmin) can be used as an index.

PRINTER/DUPLICATOR MONITORING SHEET

Printer No. 2 Film Type: [✓] Silver [ ] Diazo [ ] Vesicular
Film Size: [ ] 16mm [✓] 35mm [ ] 105mm

Dates: 8-17, 8-18, 8-19, 8-20, 8-21, 8-24, 8-25, 8-26, 8-27, 8-28, 8-31, 9-1, 9-2, 9-3

Test Patch Density at Exposure Setting: 70 volts



****

Density Uniformity (16 mm & 35 mm)

Edge	1.36	1.41												
Center	1.39	1.45												
Edge	1.42	1.48												
Diff:	0.06	0.07												

****

Density Uniformity (105 mm)

UL	1.29													
CL	1.29													
LL	1.25													
UC	1.31													
CC	1.34													
LC	1.39													
UR	1.29													
CR	1.42													
LR	1.47													
Diff:	0.18													

****

Resolution (16 mm & 35 mm) Aim Pattern: 7.1

Edge	6.3	7.1												
Center	7.1	7.1												
Edge	5.6	7.1												

****

Resolution (105 mm) Aim Pattern: 7.1

UL	7.1													
CL	6.3													
LL	6.3													
UC	6.3													
CC	6.3													
LC	6.3													
UR	6.3													
CR	6.3													
LR	5.6													

Figure 6 — Example of printer/duplicator monitoring form

10.2 Diazo development control

10.2.1 Method A: Preferred method for production use

The diazo film should be aerated after development for at least 5 min at room temperature in the dark. Two identified and identical areas of the processed diazo film having visual density equal to or greater than 1.0 should be read for visual diffuse transmission density as described in ANSI IT9.5, paragraph 8.1.1. One of the identified areas should then be covered with an opaque material. This sample should be placed at a distance of 100 mm from a 100 watt (W) clear incandescent lamp. After being exposed for 2 min with the lamp turned on, the sample should be removed and redeveloped. The density of the identified areas should be read again for visual diffuse transmission density. Any density differences should be expressed as a percentage of the original density of the re-exposed areas. However, in case of conflict, the results of the tests specified in ANSI IT9.5 take precedence.

10.2.2 Method B: Alternate method without densitometer for low volume

Place a UV opaque mask such as a piece of cardboard with a window cut out in contact with the sensitized side of the diazo film to be used. Give this configuration full exposure and develop normally. (See figure 7.)

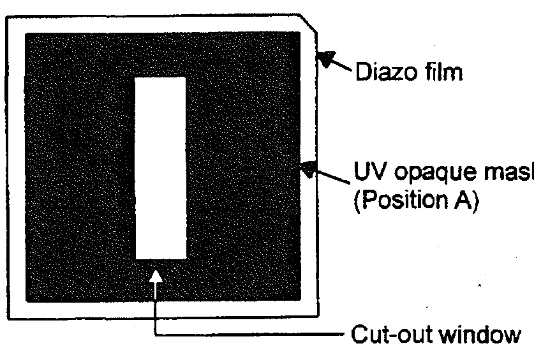


Figure 7 — Mask for determining diazo full development (Method B, Position A)

Turn the mask 90° and fully re-expose and redevelop this configuration. (See figure 8.)

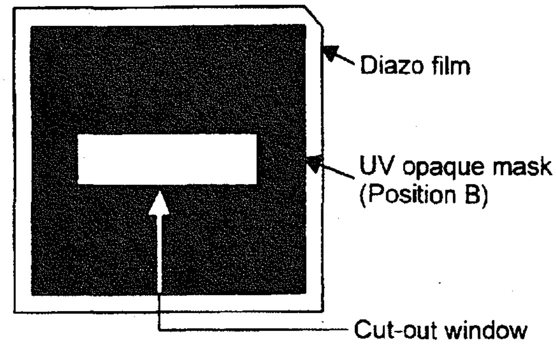


Figure 8 — Mask for determining diazo full development (Method B, Position B)

Results: If the diazo film has been fully developed, no ghosting or weak image will be visually apparent. Figure 9 shows film that was fully developed with a normal single pass through the development section.

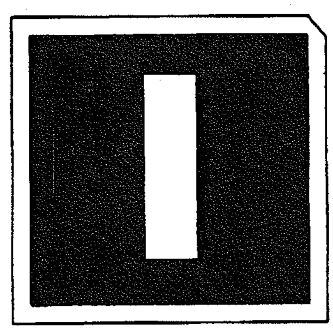


Figure 9 — Fully developed film

If the diazo film was not fully developed during the first cycle, a ghosting or weak image will be apparent after the second development. Figure 10 shows film that was underdeveloped. Make the necessary process adjustments and repeat the test.

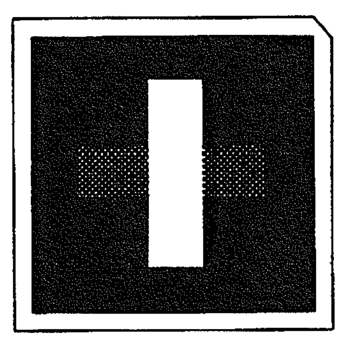


Figure 10 — Partially developed film

11 Density guidelines for duplicate microfilms

11.1 Density guidelines for duplicates from document microfilms

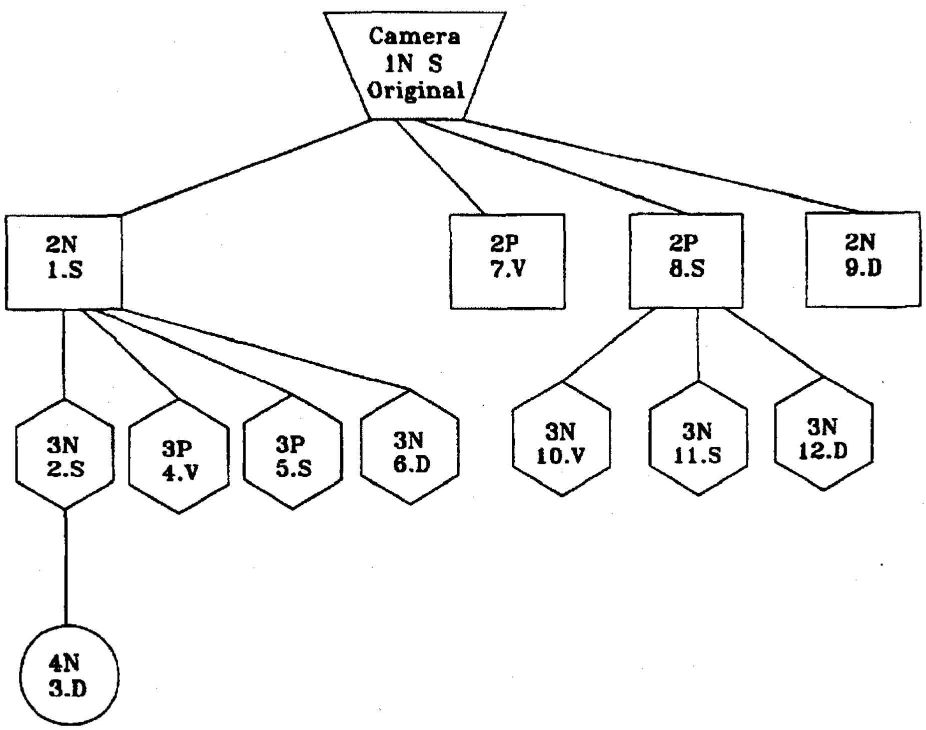
Duplicate densities are dependent on the density of the camera film and the gamma of the duplicate film. Because the density of the camera film can vary significantly depending on the type of hardcopy imaged (see table 1), the densities of the duplicates will also vary. In general, the lighter the background density of the camera negative, the lighter the background density of the duplicate.

Because of limitations in most micrographic systems, thin lines in the original document will tend to fill in when filmed, as a function of their width and density. Therefore, as the reduction ratio of a given system is increased, it may be necessary to reduce the background density to achieve an image with relatively low line density so that the copies produced will contain legible characters.

Figure 11 shows several common duplicating systems. Table 5 gives densities for the duplicates outlined in figure 11, assuming an acceptable camera negative with a background density of 1.10. These numbers, though valid for most types of document microfilming, may vary depending on the quality of the hardcopy and original camera negative. This example may not be valid for low-contrast microform systems.

Release or distribution copies, regardless of generation, must be of sufficient background density to be usable. This density will vary slightly depending on the type of hardcopy imaged. The minimum density (*D*min) must be low enough to ensure optimum image quality and printability (see 11.3.2). This low *D*min is especially important if the duplicate is to be used in a reader-printer. The ultimate density criterion is for the duplicate to be of satisfactory quality for its intended use — direct viewing, duplicating to film, or making hardcopy prints.

The final product should be evaluated to determine if legible microimages have been achieved. A practical evaluation of the output quality can be made by inspecting the film on a reader, by making full-size reader/printer copies, or by making a subsequent microfilm generation.



Note: The number and letter in each block refer to the generation and polarity, respectively. The letter in the lower right-portion of the block designates film type: "S" for silver, "V" for vesicular, and "D" for diazo. The number in the lower left corner refers to the appropriate "Block" entry in table 5.

Figure 11 — Common duplicating systems

Table 5 — Densities for duplicate microforms of source documents

	Block	Background densities	*D*min
1N camera original (master)	**N/A**	**1.10**	**0.1 max.**
2N silver (sign-maintaining intermediate film, low-contrast)	1	1.10 minimum	0.15 - 0.25
2N silver (sign-maintaining film, medium contrast)[1]	1	1.40 minimum	0.10 - 0.20
3N silver (sign-maintaining film, medium contrast)	2	1.40 minimum	0.10 - 0.20
4N diazo (high contrast)	3	1.50 minimum	0.05 - 0.10
4N diazo (medium contrast)	3	1.30 minimum	0.05 - 0.10
3P vesicular	4	1.80 - 2.20	0.20 maximum
3P silver	5	1.10 - 1.60	0.15 maximum
3N diazo (high contrast)	6	1.50 minimum	0.05 - 0.10
3N diazo (medium contrast)	6	1.30 - *D*max	0.05 - 0.10
2P vesicular	7	1.80 - 2.20	0.20 maximum
2P silver	8	1.20 - 1.50	0.15 maximum
2N diazo (high contrast)	9	1.50 minimum	0.05 - 0.10
2N diazo (medium contrast)	9	1.30 - *D*max	0.05 - 0.10
2N diazo (low contrast)	9	1.0 minimum	0.05 - 0.10
3N vesicular	10	1.50 -1.70	0.20 maximum
3N silver[1]	11	1.10 - 1.30	0.10 maximum
3P diazo (high contrast)	12	1.50 minimum	0.05 - 0.10
3P diazo (medium contrast)	12	1.30 - *D*max	0.05 - 0.10

NOTES

These densities are recommended for documents filmed with a background density range of 1.00 to 1.30 for documents described in table 1 and ANSI/AIIM MS23 as Group 1: High-quality, high-contrast printed books, periodicals, and black typing; fine-line originals, black opaque pencil writing, and documents with small, high-contrast printing.

[1] Lower *D*min values than those specified in the table are allowable provided they are at least 0.01 greater than the native *D*min of the duplicating film being used. See also the manufacturer's recommendation.

11.2 Density of distribution copies from COM microfilm

The summary of acceptable density limits is contained in table 2 and is the same as in *table 1 in ANSI/AIIM MS1*. A direct-image COM camera film is a film that produces negative-appearing images with a conventional process (IN).

11.2.1 Negative-appearing (2N) vesicular film

The f/4.5 projection density of the background of vesicular COM duplicates should be a minimum of 1.8. One study has shown that optimum exposures using vesicular film occur when the background density is approximately 85 % of the maximum density of fully exposed film.

11.2.2 Negative-appearing (2N, 3N, 4N, etc.) diazo film

The visual diffuse density of the background of diazo COM duplicates should be a minimum of 1.3 and preferably a minimum of 1.5. High-volume distribution of diazo duplicates with prestriped headers requires a 4N prestriped diazo duplicate.

11.2.3 Positive-appearing (2P, 3P, etc.) film

Because positive-appearing distribution copies are rarely used with COM, recommended values are not included in this document.

11.3 Reproducibility and printability

11.3.1 Reproducibility

All characters must be recorded so that they can be read easily by users, which means that the quality of the first-generation camera film must be sufficiently high to allow for the normal image degradation that results when making subsequent-generation copies. The maximum acceptable loss is about one resolution pattern for each subsequent generation. The duplication step should result in the loss of not more than one resolution pattern between camera film and duplicate. The viewer should evaluate the film in a reader similar to that used by the end user.

11.3.2 Printability

The manufacturer should consider end users' intended applications and make sure the microform is usable in their system. Ideally, tests should be made that duplicate the conditions under which the microform will be used. If the end user is going to duplicate the microform onto hardcopy or another microform, the manufacturer should ensure satisfactory reproduction by test-printing the microform on the same or similar equipment.

11.3.3 Troubleshooting

Table 6, table 7, table 8, table 9, and table 10 are troubleshooting guides for silver, diazo, and vesicular duplicates from source-document or COM-produced microforms. Some of the problems listed appear on the original camera film and then are copied onto the duplicate film.

12 Inspection

12.1 Inspection equipment and supplies

See figure 12 for examples of inspection equipment and supplies.

12.1.1 Inspection report forms

Reporting forms such as the one in figure 13 should be provided for the inspector to record the results of the inspection. (Sample forms appear in annex A.)

12.1.2 Inspection gloves

Lint-free gloves should be used to prevent marking of the film by fingerprints.

12.1.3 Light box

When inspecting microfilm, a light box is necessary. This box should contain lights and have a diffuser of translucent material at least 125 mm by 250 mm in size.

12.1.4 Rewinds

When inspecting microfilm in roll form, a set of rewinders along with reels and flanges are necessary. A power rewind is a work-saving convenience when inspecting long rolls.

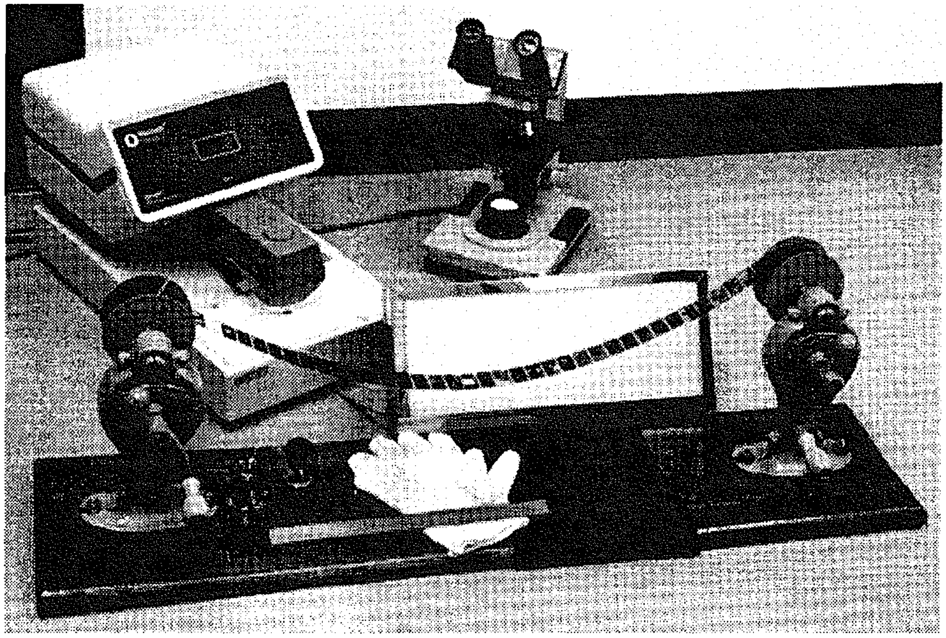


Figure 12 — Microfilm inspection equipment

12.1.5 Ruler

A ruler is useful when measuring the distance between repeating defects or marks. It may offer a clue as to what is causing the mark or defects.

12.1.6 Optical measuring loupe

A hand-held magnifying glass having a power of 8 or more should be used. An optical loupe with a measuring reticle is useful for determining the reduction ratio of the image on film.

12.1.7 Black velvet

A swatch of black velvet 150 mm by 300 mm is useful for detecting scratches, abrasions, water spots, and so on. The inspector views the subilluminated film while looking towards the velvet. See figure 14.

12.1.8 Microform reader or reader-printer

A reader in which a section of film can be easily inserted and removed edgewise, without damage, is useful in determining the visual effect of various defects.

12.1.9 Densitometer

The densitometer shall be a transmission type designed to measure visual diffuse density according to ANSI/ISO 5-2 and ISO 5-3. If the densities of vesicular or diazo films are to be measured, use a densitometer for measuring the projection density of vesicular film and diffuse density of diazo and silver films. The densitometer shall be operated according to manufacturer's instructions and should be adjusted to read a calibrated step tablet to an accuracy of ±0.02 and a repeatability of ±0.01 between a density of 0 and 2.00.

12.1.10 Microscope

A high-quality microscope should be used to determine the smallest resolution test pattern resolved on the microfilm. Use a microscope that has a good quality achromatic objective. Its magnification shall be between 1/3 and 1 times the expected system's resolving power when the microform is examined. For example, to view an image produced by a system with a resolving power of 150 lp/mm, the magnification shall be between 50:1 and 150:1.

INSPECTION REPORT FORM

INSPECTOR NAME: Rick

INSPECTOR NUMBER: 305 | DATE: 11-21-95 | WEEK NUMBER: 55

ORDER TYPE	TRAVELER NUMBER	FILM REQ'ST	PROG. NO.	TOTAL ROLLS	√	ROLL TO BE REPRINTED	REPRT. CODE	FILM & SET'NGS	SAME SET??	MACH. NO.	OPER. NO.	PRNT. DATE	OTHER COMMENTS
FHC	154501-13	V	133	57		1254050	02	SR40	N	E2	111	11/21	Dark at end
						1035735	09	V110	Y	V1	134	11/21	Blurring

TOTAL INSPECTED:	TOTAL REPRINTED:	REPRINT CODES:	FOOTAGE SCRAPPED
57	2	01 LIGHT, 02 DARK, 03 FOCUS, 04 TAPE, 05 SIZE, 06 NUMBER, 07 TYPE, 08 COPIES, 09 PRINTER, 10 BLURR, 11 MISTRACK, 12 PROC'SOR, 13 STOCK, 14 MISC., 15 OPERATOR, 16 PRE-PROG.	200 ft
		ORDER TYPES: MR FHC DUP RUSH GSC MACHINE CODES: X1 X2 X3 X4 S1 S2 S3	

Figure 13 — Inspection report form

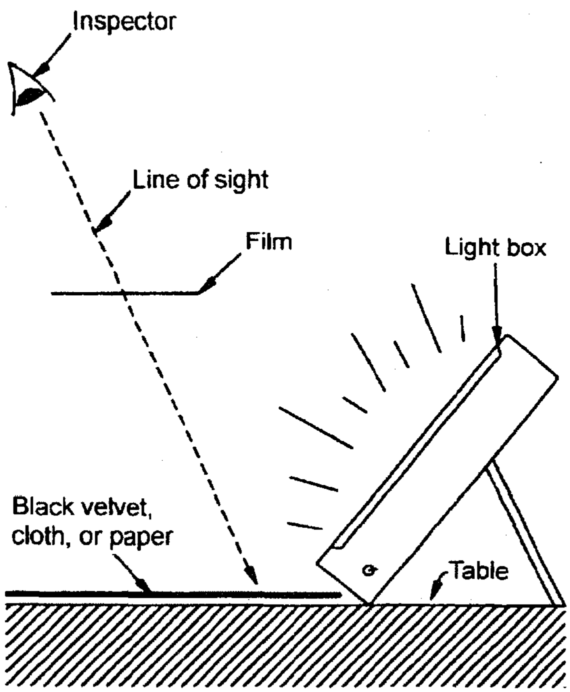


Figure 14 — Inspection using black velvet

12.1.11 Step tablet

A step tablet is a length of film containing gradations of density. For work required to conform to specifications, the calibrated step tablet should comply with NIST certification requirements. Satisfactory step tablets for day-to-day testing may also be purchased from commercial manufacturers.

12.1.12 Residual thiosulfate test materials

If needed, the required instruments, glassware, and reagents necessary to perform the methylene blue, iodine amylose, and silver densitometric tests are described in ANSI/NAPM IT9.17. This test is necessary for most if not all long-term data retention retirements.

12.1.13 Defect samples

Defect samples are a good training aide for new inspectors as well as a practical way of establishing consistent accept/rejection criteria.

(Main text continues on page 45.)

Table 6 — Troubleshooting guide for general duplication problems using silver film

Problem	Possible Causes	Solutions
Uneven density	Printer's exposing lamp is out of balance. Obstruction is in the duplicator light path. Printer lamp filament configuration has been changed.	Reposition printer lamp for uniform output. Check light path for dirt, film chips, paper, etc. Replace printer lamp and balance output.
Edge fog	Roll film has been excessively exposed to safelight. Roll film has been exposed to incorrect safelight or white light.	Conduct safelight test. Limit safelight exposure. Check safelight filter and lamp wattage. Check for white light leaks.
Intermittent fog	Film has been exposed to white light for a short duration, e.g., an opened door. Film has been exposed to white light from nearby electric motor spark.	Prevent accidental exposure; lock doors. Shield light coming from motor.

(continued)

Table 6 — Troubleshooting guide for general duplication problems using silver film *(continued)*

Problem	Possible Causes	Solutions
Uniform colored fog (dichroic)	Developer is contaminated with fixer, potassium borohydride, or copper. Emulsion surface has been subjected to excessive oxygen during development.	Dip piece of unfogged sign-reversing film in developer for normal dwell time; *D*min should be below 0.10. Replace developer if test fails.
Out of focus, intermittent	Supply-and-take-up clutch tensions are incorrect on printer. Diameters of master and raw stock rolls are too dissimilar. Slippery substance is on rollers or master. Rollers are glazed. Film width varies. Vacuum is low (on printer equipped with vacuum heads). Duplicator rollers are not turning smoothly and freely.	Measure and set clutch tensions to specifications. Create larger master rolls. Clean printer rollers and master. Clean and roughen printer rollers. Measure film width; check with manufacturer. Check vacuum source; replace vacuum head rollers. Determine that rollers turn freely.
Out of focus, continuous	Master and/or raw stock have been threaded upside down. Poor contact is made between master and raw stock. Pinch rollers are not seated. Film is not threaded around capstan rollers. Pressured pad is not seating properly.	Check emulsion orientation; emulsion sides of master and raw stock must face each other. Check all rollers and film threading path. Check all tensioning devices and pressures.
Out-of-focus, elongated or compressed images	Master and raw stock are moving at significantly different rates through printer. Diameters of master and raw stock rolls are significantly different.	Check tensions of supply-and-take-up spindles and adjust. Try rolls of same diameter.
Double images	Film has been exposed twice (double exposed).	Check the handling procedures that created confusion.

(continued)

Table 6 — Troubleshooting guide for general duplication problems using silver film *(continued)*

Problem	Possible Causes	Solutions
Ghost images	Emulsion surfaces of master and raw are stock not facing each other. Printer rollers are shiny or reflective. There is a secondary source of exposing light. Master and raw stock are slipping during exposure. Master and raw stock are not in tight contact during exposure. Configuration of light source is casting elongated shadows of master image. Card printers have improper shutter timing. Printer has a faulty design.	Provide emulsion-to-emulsion contact. Replace or anodize printer rollers to be non-reflective. Check for a nearby source of unwanted light. Check supply and take-up spindle tensions. Check and adjust tensioning device.
Water spots	Water droplets with high dissolved solids content are drying on film.	Provide more complete removal of final rinse water. Provide a final dip rinse in water that contains a surfactant such as Kodak Photoflo™ or the equivalent.
Scratches	Film has misthreaded on the printer or processor. Rollers are not turning freely on printer or processor. Rubber squeegees are not adjusted properly on processor. Sand or grit is trapped in the processor squeegee. Foreign objects in processor tanks are rubbing film. Film is being scratched on reader during inspection.	Check threading path. Check all rollers and squeegees. Install particle filters on chemical and water lines. *Drain processor tanks and inspect.*
Reticulation (crazed emulsion surface)	Gelatin is rapidly shrinking due to thermal shock or pH shock.	Maintain processing solutions within ten degrees of each other. Check pH level of processing solutions.

(continued)

Table 6 — Troubleshooting guide for general duplication problems using silver film *(concluded)*

Problem	Possible Causes	Solutions
Mottled density	Developer agitation on processor is inadequate. Mottle is present in printing master. Printer has non-uniform light distribution.	Check developer recirculation pumps and turbulators, if equipped. Check printing master to verify uniform density. Check printer lamp output distribution by exposing raw film stock to a mid-range density and measure density evenness.
Newton rings, patterns of light and dark concentric rings	Extremely smooth film surfaces in tight contact are refracting printer light into "rainbow" of colors.	Decrease minimum density on sign-maintaining film masters. Use films with anti-Newton ring coating. Note: Diminishing contact pressure on printer may cause resolution loss. Because Newton rings indicate good printer contact, consider living with them.
Milky appearance	Fixing is inadequate. Dwell time in fixer is too short. Fixer is weak or diluted — thiosulfate ion concentration is low. Normally heated fixer is too cold. Solution level is low in tank. Silver ion concentration in fixer is too high.	Dip piece of raw film stock in fixer; milkiness should clear in half the available fixing dwell time. Check fixer temperature and mixing procedures. Analyze fixer for thiosulfate ion. Check for developer wash water being carried into fixer. Check silver concentration in fixer.
Solid gray areas appear excessively grainy	Processing conditions are not proper; this may be a raw film problem.	Consult film manufacturer.
Colored marks, red or yellow	Oil, grease, wax, or silicone on raw film is preventing dye removal, developing, and fixing.	Check for source; clean, and correct.
Film covered with white powdery residue	Final wash water is inadequate or lacking.	Provide ample final wash water and flow.

Table 7 — Troubleshooting guide for general duplication problems using sign-reversing silver film

Problem	Possible Causes	Solutions
Blank film, clear	Film is not exposed. Film is extremely underexposed. Film is extremely underdeveloped. Printer lamp burned out or is turned off.	Check printer lamp. Check exposure setting on printer. Dip piece of light-struck film in developer for normal dwell time; manufacturer's recommended *D*max should result. Replace developer if test fails.
Blank film, black	Film is extremely overexposed. Film was light-struck or severely fogged. Developer is contaminated with fixer or potassium borohydride (see ANSI/NAPM IT9.17).	Check exposure setting on printer. Check printer for fused exposure lamp filament and replace. Try fresh batch of film. Dip piece of unfogged sign-reversing film in developer for normal dwell time; *D*min should be below 0.10. Replace developer if test fails.
Characters blossomed (fat) on positive copy	Negative master contains blossomed characters. Density of negative master is too low. Printer exposure is too high. Negative master has low resolution. Printer resolution is loss excessive. There was poor film-to-film contact on printer.	Check master for blossomed characters. Increase master density. Decrease printer exposure. Conduct full range exposure series and choose best level. Check resolution of negative master. Test printer resolution loss (should not exceed one test chart pattern).
Character blossomed (fat) on negative copy	Positive master contains blossomed characters. Density of positive master is too high. Positive master has low resolution. Printer resolution is loss excessive. There was poor film-to-film contact on printer.	Check master for blossomed characters. Decrease master density. Check resolution of positive master. Test printer resolution loss (should not exceed one test chart pattern). Conduct full range exposure series and choose best level.
Characters light, thin, and broken on positive copy	Characters are light and thin on source document. High-density areas of camera negative are too dark. Exposure on printer is too low.	Decrease camera negative density. Provide appropriate master density. Conduct full range exposure series and choose best level.

(continued)

Table 7 — Troubleshooting guide for general duplication problems using sign-reversing silver film *(continued)*

Problem	Possible Causes	Solutions
Characters dark and filled-in on negative copy	Positive master is too light. Characters on positive master are light, thin, and broken. Exposure on printer is too high.	Provide appropriate master density. Provide master with darker, thicker characters. Reduce exposure on printer.
Medium density areas too dark on positive copy	Exposure on printer to too high. Density of negative master is too low.	Conduct full range exposure series and choose best level. Increase negative master density.
Low-density areas too dark on positive copy	High-density areas of negative master are too light. Exposure on printer is too high. Film was excessively developed. Chemical fog is coming from processor.	Provide appropriate master density. Conduct full range exposure series and choose best level. Check processor speed and temperature. Check for contaminated developer. Dip piece of unfogged sign-reversing film in developer for normal dwell time; *D*min should be below 0.10. Replace developer if test fails.
Low-density areas too dark on negative copy	Exposure on printer is too high. High-density areas of master are too light.	Decrease exposure on printer. Increase master density.
High-density areas too light on positive copy	Low-density areas of negative master are too dark. Exposure on printer is too low.	Check low-density areas of negative master. Provide master with correct density. Conduct full range exposure series and choose the best level.
High-density areas too light on negative copy	Low-density areas of positive master are dark and muddy. Exposure on printer is too low. Film is underdeveloped.	Provide master with lower minimum density. Conduct full range exposure series and choose best level. Check processor speed, developer temperature, and activity.
High-density areas too dark on positive copy	Low-density areas of negative master are too light. Exposure on printer is too high.	Check low-density areas of negative master. Provide master with higher minimum density. Conduct full range exposure series and choose the best level.

(continued)

Table 7 — Troubleshooting guide for general duplication problems using sign-reversing silver film *(concluded)*

Problem	Possible Causes	Solutions
High-density areas too dark on negative copy	Exposure on printer is too high.	Conduct full range exposure series and choose best level.
High-density spots on a clear background	Low-density spots, pockmarks, or pinholes are in high-density area of master. Contamination is coming from powders or liquids with sensitize film emulsion.	Check master and replace.
Low-density spots on dark background	Film dust is embedded into clear areas of master. Fixer was splashed onto film before development. Carbon dioxide gas has been liberated during processing.	Replace master. Check for high-speed processor rollers slinging fixer. Check pH of processing solutions; high-pH developer followed by low-pH acetic acid stop bath may liberate carbon dioxide, which will burst the emulsion layer.
High-density spots on dark background	Developer is splashing onto film before development.	Check for high-speed processor rollers slinging developer.
Static fog marks, low density	High-density static fog marks are on negative master.	Check master for high-density static fog marks. Create and use unfogged master.
Static fog marks, high density	Film has no anti-static coating. Film is being wound at high speed at low relative humidity. Printer or processor is not electrically grounded Film is rubbing against non-conductive materials. Low-density static fog marks are on negative master.	Use films with anti-static coatings. Increase ambient humidity levels. Provide electrical grounding. Switch to metal (conductive) materials where possible. Check master for low-density static fog marks. Create and use unfogged master.

Table 8 — Troubleshooting guide for general duplication problems using sign-maintaining silver film

Problem	Possible Causes	Solutions
Blank film, clear	Film is light-struck or severely fogged. Film is extremely overexposed. Printer exposure lamp filament fused. Film is extremely underdeveloped.	Try a fresh batch of film. Check exposure setting on printer. Check exposure lamp filament. Dip piece of unfogged sign-maintaining film in developer for normal dwell time; manufacturer's recommended *D*max should result. Replace developer if test fails
Blank film, black	Film not exposed. Film is extremely underexposed.	Check printer for proper exposure lamp operation. Check exposure setting on printer.
High-density areas too light on negative copy	High-density areas are too light on master negative. Exposure on printer is too high. Film is underdeveloped.	Provide appropriate master density. Conduct full range exposure series and choose best level. Check processor speed, developer temperature, and activity.
High-density areas too dark on negative copy	High-density areas are too dark on negative master. Exposure on printer is too low.	Provide appropriate master density. Conduct full range exposure series and choose best level.
Low-density areas too dark on positive copy	Low-density areas are too dark on positive master. Exposure on printer is too low. Film is excessively developed.	Provide appropriate master density. Conduct full range exposure series and choose best level. Check processor speed and temperature.
Static fog marks, low-density	Film has no anti-static coating. Film is being wound rapidly at low relative humidity. Printer or processor is not electrically grounded. Film is rubbing against non-conductive materials. Low-density static fog marks are on master.	Use films with anti-static coatings. Decrease winding speed. Increase relative humidity. Provide electrical grounding. Switch to metal (conductive) materials where possible. Check master for same static fog marks. Provide unfogged master.

(continued)

Table 8 — Troubleshooting guide for general duplication problems using sign-maintaining silver film *(concluded)*

Problem	Possible Causes	Solutions
Static fog marks, high density	High-density static fog marks are on master.	Check master for same static fog marks. Provide unfogged master.
Low-density spots	Low-density spots are on master. Carbon dioxide was liberated during processing. Fixer was splashing onto film before development.	Replace master. Check pH of processor solutions; high-pH developer followed by low-pH acetic acid stop bath may liberate carbon dioxide gas, which will burst emulsion layer. Check for high-speed processor rollers slinging fixer.

Table 9 — Troubleshooting guide for general duplication problems using diazo film

Problem	Possible Causes	Solutions
Blank film, clear	Raw film was totally fogged before development. Film was improperly handled and stored. Film is not developed.	Correct handling procedures. Check ammonia delivery and temperature.
Blank film, dark	Raw film was not exposed.	Check exposure section of duplicator.
Uneven density	Duplicator exposure is not uniform. Raw film is partially fogged. Development is inadequate or weak.	Balance exposure source. Try new batch of raw film. Check ammonia delivery and temperature.
Characters blossomed (fat) on positive copy	Positive master had blossomed characters. Film is underexposed. Poor contact has been made between master and duplication film stock.	Check master for similar character formation. Conduct full range exposure series and choose best level.
Characters blossomed (fat) on negative copy	Negative master had blossomed characters. Film is overexposed. Poor contact has been made between master and duplication film stock.	Check master for similar character formation. Conduct full range exposure series and choose best level.

(continued)

Table 9 — Troubleshooting guide for general duplication problems using diazo film *(continued)*

Problem	Possible Causes	Solutions
Characters thin and light on positive copy	Positive master had thin and light characters. Film is overexposed.	Check master for similar character formation. Conduct full range exposure series and choose best level.
Characters dark and filled-in on negative copy	Low-density areas too high on negative master. Film is underexposed.	Check low-density areas of master. Conduct full range exposure series and choose best level.
High-density areas too light on positive or negative copy	Development was inadequate. High-density areas are too low on master. Film is overexposed. Raw stock is old. Raw stock was improperly stored. Raw stock is fogged.	Check ammonia delivery and temperature. Provide master with adequate background density. Conduct full range exposure series and choose best level. Try new batch of raw film.
Low-density areas too dark	Low-density areas are too dark on master. Film is underexposed.	Provide master with adequate *D*min. Conduct full range exposure series and choose best level.
Color is greenish/yellow	Development was incomplete.	Check ammonia delivery and temperature.
Color is brownish/purple	Development temperature is too low.	Increase development temperature.
Color is too blue (Black diazo film type)	Development temperature is too high. Incorrect film type was used. Humidity is too low.	Decrease development temperature. Check film type. Increase relative humidity for aqueous ammonia systems.
Image dye color at edges	Film was stored in environment with ammonia.	Store film away from ammonia fumes.
Out of focus	Master is out of focus. Poor contact has been made between master and duplicating stock. Emulsion sides of both films were not in contact.	Check resolution/sharpness of master. Ensure even and adequate pressure during exposures. Ensure emulsion-to-emulsion contact during exposure.

(continued)

Table 9 — Troubleshooting guide for general duplication problems using diazo film *(concluded)*

Problem	Possible Causes	Solutions
Ghost images	Exposure begins before films are in tight contact. Exposure continues as films begin to separate. Outgassing of film upon exposure separates films and permits sliding.	Correct exposure timing/pressure plated sequence. Use non-slip diazo film.
Double images	Film was exposed twice (double exposed)	Correct the situation that created the confusion.
High-density spot that blocks information, surrounding areas out of focus	Sizable dirt particle between master and raw stock prevented exposure and emulsion-to-emulsion contact	Maintain clean environment. Clean masters.
Water spots	Water condensed in developer chamber of aqueous ammonia systems.	Check developer-section temperatures. Check for leaking gaskets, which could permit cool air to enter, causing moisture to condense.
Newton rings, patterns of light and dark concentric rings	Smooth film surfaces in imperfect contact refract light into a "rainbow" of colors.	Use films with anti-Newton ring coatings. Note: Decreasing duplicator contact minimizes Newton rings but increases resolution loss. May be impossible to prevent.

Table 10 — Troubleshooting guide for general duplication problems using vesicular film

Problem	Possible Causes	Solutions
Blank film, clear	Film is not exposed. Film base is not coated with light sensitive material. Film is not developed.	Check lamphouse, exposure setting, and shutter mechanism. Try different film batch number. Check development temperature and dwell time.
Blank film, black	Film is extremely overexposed. Raw film stock was fogged (exposed to ultraviolet light). Film is extremely overdeveloped.	Check lamphouse, exposure setting, and shutter mechanism. Try different film batch number. Check development temperature and dwell time.

(continued)

Table 10 — Troubleshooting guide for general duplication problems using vesicular film *(continued)*

Problem	Possible Causes	Solutions
Blossomed (fat) characters	Master has low background density. Master has blossomed characters. Film is overexposed. There was poor film-to-film contact on duplicator.	Check master density; provide adequate background density. Check master for similar-appearing characters. Conduct full range exposure series and choose best level. Conduct resolution loss test on duplicator.
Characters light, thin and broken on positive copy	Negative master is too dense. Film is underexposed. Film is underdeveloped. Master is out of focus.	Check master density and provide correct *D*min. Check exposure level. Check development temperature and dwell time. Check focus on master.
Characters dark and filled in on negative copy	Characters on positive master are thin and light. Film is overexposed. Film is overdeveloped.	Check characters on positive master. Conduct full range exposure series and choose best level. Drop density below absolute maximum density of film. Check development temperature and dwell time.
Uneven density across film	Film is unevenly exposed.	Check exposure lamp alignment and adjust. Check for dirt on mirrors and glass flats. Check for obstructions in light path.
Low background density	Low-density areas of master are too high. Film is underexposed. Film is underdeveloped.	Check density of master. Check exposure section for intensity and dwell time. Check development temperature and dwell time.
Repeating orange (sepia) spots in high-density areas	Dirt on heater surface prevents heat transfer.	Clean heater surface.
Medium density areas brown or sepia	Film was underdeveloped; bubble size is too small.	Check development temperature and dwell time.

(continued)

Table 10 — Troubleshooting guide for general duplication problems using vesicular film *(concluded)*

Problem	Possible Causes	Solutions
Grainy appearance, background gray and not black, burst bubbles	Film was overdeveloped; bubble size is too large.	Check development temperature and dwell time.
Film is greenish/yellow	Clearing is insufficient.	Check clearing lamp output and dwell time.
Unwanted density in clear areas	Pre-exposure is excessive. Film is fogged due excessive ambient lighting	Check pre-exposure section for proper setting. Protect film from white-light fogging.
Ghost images	There was poor emulsion-to-emulsion contact during exposure. Shutter mechanism is opening before films are in tight contact. Shutter mechanism is staying open after films begin separating.	Check platen pressure or belt tension. Check shutter timing.
Low-density, beige colored lines in high-density areas	Extreme localized pressure is collapsing bubbles.	Check duplicator for sticking rollers.
Newton rings, patterns of light and dark concentric rings	Smooth film surfaces in imperfect contact refracts light into a "rainbow" of colors.	Increase background density if possible.

(Main text continues here from page 33.)

12.1.14 Indelible pen

Indelible pens are pens with indelible ink that remains through processing solutions. Such pens are used for label information marking and defects. The pen ink should be checked for photographic activity.

12.1.15 Collimated light source

A collimated light source is useful for detecting surface defects that may not show under normal transmitted or reflected room light.

12.2 Inspection procedure

12.2.1 Inspection report

Transcribe, from the film, attached labels, or both, all appropriate identification information to the inspection report form. (See figure 13.)

12.2.2 Procedures

The inspector should wear clean, lint-free gloves. Using rewinds, the inspector slowly advances the film over the light box, noticing contrast, density level, density evenness across the film, light or dark streaks, dirt, printed-in dirt, out-of-focus images, scratches, or other defects noted in table 11. The inspector should stop every 5 ft to 10 ft (or when the type of subject matter changes) and carefully examine the film, using the optical magnifier, for text quality and character formation. If a defect is suspected, it is helpful to have a microfilm reader into which the film can be easily inserted for full-size viewing and evaluation. The subilluminated film should be viewed frequently toward the black velvet cloth for possible scratches or water spots.

Table 11 — Defects classification guide

	Major	Minor
Blank film, clear	X	
Blank film, black	X	
Bromide streaks		X
Density too high/too low		X[1]
Density uneven		X[1]
Double exposure	X	
Dust/dirt images		X
Fingerprints		X
Fog (all types)		X[1]
Foreign material on film		X[1]
Frilling (peeling emulsion layer)	X	
Green vesicular film		X
Illegible text	X	
Milky appearance	X	
Mottled density		X
Newton rings		X
Duplicator tracking problems		X
Orange spots on vesicular film		X
Out of focus (loss of contact on duplicator)	X	
Out of focus (emulsion sides not in contact)	X	
Out of focus (poor contact on duplicator)	X	
Out of focus (stretched/compressed images)	X	
Pressure marks		X[1]
Raw stock defects		X[1]
Resolution loss (more than one pattern)	X	
Excessive thiosulfate	X	

(See notes on next page.)

(continued)

Table 11 — Defects classification guide *(concluded)*

	Major	Minor
Reticulation	X	
Roller marks on edges		X
Scratches (all types)		X[1]
Static marks		X
Streaks		X[1]
Washboard, high/low-density cycling		X
Water spots		X

NOTES

1 Major defects negatively impact life expectancy or interfere with making and using final generations.

2 Minor defects are cosmetic only and do not negatively impact life expectancy or interfere with making and using final generations.

[1] Might be major depending upon severity and impact on usability and life expectancy.

Resolution targets on the film should be evaluated under a microscope to determine if the resolution loss from printing is acceptable; a 1/2-pattern loss per generation is attainable on high-quality contact roll-to-roll printing devices. The maximum acceptable loss is one pattern per generation. Microfilm jacket originals may result in more than one test pattern loss in the duplicate (see ANSI/AIIM MS11). The legibility of the image should be verified. (See also ANSI/AIIM MS23.)

Density measurements should be made at random throughout the roll. Five readings per 1000 images should be sufficient unless hardcopy reflectance, camera lighting, and/or printer exposure has been intentionally changed. Examples of statistical sampling plans are in ISO 2859 or ANSI/AIIM TR34. Common sense should be used in any sampling plan. Any changes in the process of equipment procedures necessitate more frequent inspection. Changes in the system will initially necessitate more frequent inspection until a satisfactory level of performance is achieved.

Results should be logged on the inspection report form. If necessary, refer to tables 6 through 10 for possible sources of film defects problems.

The defects listed in 12.3 are based on a satisfactory original film. Poor quality originals can affect duplicate quality.

Visual defects are classified as in 12.2.2.1 through 12.2.2.3.

12.2.2.1 Major defect

If vital information is obliterated, the defect is classified as major. The probable cause should be noted on the inspection report, and the identification of the affected sections should be recorded on the reprint form. Any image or images falling into this classification must be rejected and reprinted. Major defects would render the images or parts of images illegible. Immediate steps must be taken to remedy these conditions.

12.2.2.2 Minor defect

If vital information is not obliterated, the defect is classified as minor. The probable cause should be noted on the inspection report. The user can normally detect minor defects. The film is still usable, but the use could be more difficult than it should be. Steps must be taken to correct this condition as soon as possible.

12.2.2.3 Cosmetic defects

Cosmetic defects may be noticeable by the user; however, they would not affect image area or legibility. Steps should be taken to correct this condition as soon as possible.

12.3 Description of defects

See the visual defects classification guide given in table 11. What appears to be an over-exposure, under-exposure, over-developed, or under-developed copy may sometimes be due to a poor contrast master.

12.3.1 Blank film

This defect refers to film without images.

12.3.1.1 Blank silver film

Possible causes include the following:

- the film was not exposed in duplication (sign reversing);
- the exposure lamp was off;
- the film is undeveloped but has been fixed;
- the film is defective or uncoated.

12.3.1.2 Blank diazo film

Possible causes include the following:

- the film was not exposed in duplication and is undeveloped;
- the exposure light was too bright;
- the film is defective or uncoated.

12.3.1.3 Blank vesicular film

Possible causes include the following:

- the film was not exposed in duplication;
- the exposure lamp was off;
- the film is defective or uncoated.

12.3.2 Blurred, ghosted, or compressed images

Figure 15 shows severely compressed images caused by the master moving through the duplicator significantly faster than the raw stock. In films with this defect, images appear fuzzy. Having printed emulsion in contact with the base may cause an out-of-focus condition. Normally, the master and duplicate film stock are in full contact of emulsion to emulsion. This contact is necessary to produce sharp images in the duplicate commensurate with that of master film. The master or duplicate might also slip while being exposed.

12.3.3 Chemical contamination

This defect refers to silver film with either high-, medium-, or low-density spots or streaks. This defect can also entail overall fogging or loss of density. Chemical contamination prevents image formation and development, and results in a low-density spot. Chemicals may combine with developer locally to form a nonselective developer whereby unexposed as well as exposed silver-halide grains are developed; this can result in a very dark or black spot. (See figure 16.)

12.3.4 Double exposure

Two distinct sets of images will be superimposed on the film when it is double exposed. The overlapped sections of the images will appear darkened, although the outlines of each set of images will still be distinguishable. The possible cause is re-exposure, by the operator, of a previously exposed roll of film. (See figure 17.)

12.3.5 Dirt and dust

Dust or dirt will appear on the duplicate film. Dust or dirt settling on the film and blocking the exposure of images from the master during duplication causes this condition.

12.3.6 Edge fog

This defect refers to the appearance of dark margins along the edge of the film, which may or may not affect the image area or legibility. Edge fog is caused by light exposure of silver-halide, sign-reversing duplicate film. For diazo film, improper storage or out-of-date film may cause bluish to brownish edges to appear on processed film. (See figure 18.)

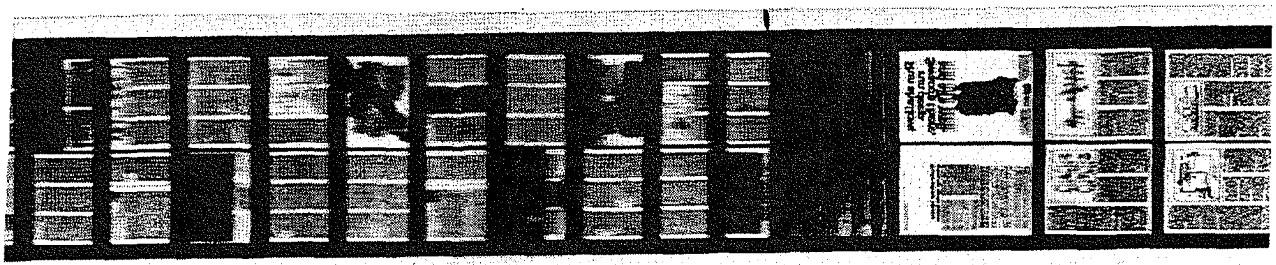


Figure 15 — Blurred, ghosted, or compressed images

Figure 16 — Chemical contamination

Figure 17 — Double exposure

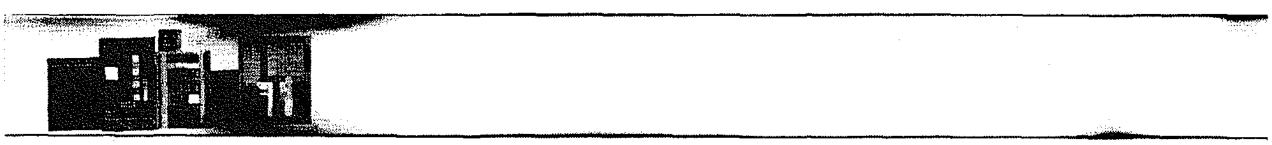


Figure 18 — Edge fog

12.3.7 Fingerprints

This defect is a visual image of a fingerprint caused by improper handling by the duplicating operator, processing technician, or inspector.

12.3.8 Fog

Fog entails darkened or black areas on the sign-reversing silver, or vesicular microfilm; or clear or light areas on sign-maintaining diazo or silver microfilms. The probable causes of fog include excessive exposure to light, exposure of film during manufacturing, chemical fog, or use of outdated film.

This defect refers to film that has nonimage density either uniformly throughout or in specific patterns. If it is quite uniform, it could be caused by

— improper dilution or contaminated developer;

— darkroom light leaks;

— improper, faded, or damaged safe lights;

— storage of raw film at high temperatures;

— or allowing film to remain too long or at too high a temperature in the developer.

If fog occurs in specific patterns, it can be caused by white light, excessive or the wrong safe light shining on the edge of the roll, or static discharge. Or particles of a contaminant, such as potassium borohydride (sensitizing chemical), can stick to the film and cause long streaks of fog (see figure 19).

12.3.9 Frilling

This defect entails the puckering and peeling of a photosensitive layer from the support of silver film during processing. Usually it is caused by

— excessive temperature;

— poor adhesion qualities of the emulsion to the base;

— improper hardening of the gelatin;

— use of extremely soft wash water;

— a combination of the above circumstances.

12.3.10 Too-dark or too-light film

Processing errors, such as processing speed or temperature (see underdevelopment or underexposure, and overdevelopment or overexposure) can cause this defect.

12.3.11 Greenish-tint film

Improperly or poorly cleared vesicular film has a greenish tint in the nonimage area. In diazo films, it could be an indication of incorrect development.

12.3.12 Marks or physical artifacts

Marks or other physical conditions include

— straight scratches from processor squeegee;

— water spots;

— stuck-together polyester;

— dark yellow-brown stains;

— foggy bubble pattern (processor stopped);

— gouged or scratched printing master;

— light streak running lengthwise (dust in the printer light);

— clear edge running lengthwise (printer slot partially out);

— torn film;

— film cut off too short in processing;

— dents or dimples in the film;

— wavy or frilled edges;

— foreign material on film (grease, slime, etc.);

— or spots in a pattern (processed upside down).

12.3.13 Milky film

This defect refers to silver film that has not been adequately fixed. Milky film can be caused by

— weak fixer solution;

— excessive silver in the fixer solution;

— too-fast processor speed;

— too-cold fixer solution;

— a malfunction of the silver recovery system.

Underexposure of vesicular film may cause milky-appearing film.

12.3.14 Mottle

This defect entails a cloudy or blotchy appearance and uneven density. Probable causes are insufficient agitation during processing (silver), improper storage conditions, or defective emulsion.

12.3.15 Newton rings (Interference)

This defect entails the appearance of images of rings seen as a result of the close contact of two smooth surfaces, at least one of which is transparent. Underexposure of vesicular film may cause apparent Newton rings.

12.3.16 Improper or off tracking

An improper tracking condition occurs when an edge of the master film is not aligned parallel with the edge of duplicate film. When critical alignment of the image is necessary (image blips), improper tracking must be considered a major defect. (See figure 20.)

12.3.17 Out of focus

This defect refers to film with fuzzy images throughout. (See figure 21.) This defect is typically caused by poor emulsion-to-emulsion contact.

12.3.18 Overdevelopment

This defect refers to, in silver film, images or *D*min or both that are darker than normal. This defect is caused when the film is developed too much because of one or more of the following: excessive time, excessive temperature, overstrength solution, or excessive agitation. Diazo film cannot be overdeveloped. With vesicular film, slight overdevelopment will cause images that are darker than normal. Greater overdevelopment will cause the surface to have a rough appearance and discoloration. These defects are caused when the film is developed too much because of excessive time, excessive temperature, or both. (See figure 22.)

12.3.19 Overexposure

This defect manifests in the following ways for each film type (see figure 23, parts a and b).

12.3.19.1 Silver, sign reversing

The images are too dark. Probable causes include too-high light intensity, too large aperture, too-long exposure time, and equipment malfunction. See figure 23, part a.

12.3.19.2 Silver, sign maintaining

Images are too light, and *D*min decreases. Probable causes include too-high light intensity, too-large aperture, too-long exposure time, or equipment malfunction. See figure 23, part b.

12.3.19.3 Diazo

The images are too light and *D*min remains below 0.10. The lines are blooming (lacking in sharpness and definition); for example, the letter "e" fills in. Probable causes include too-high light intensity, too-large aperture, or too-long exposure time.

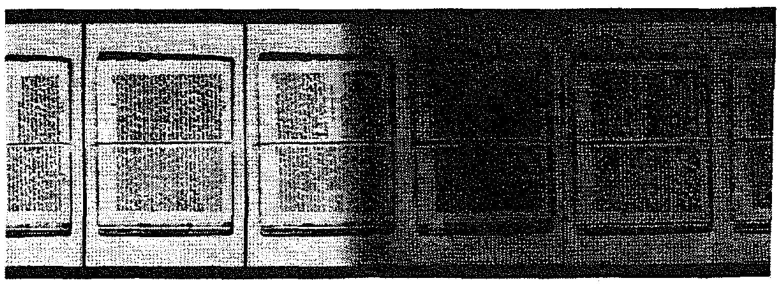


Figure 19 — Fog

Figure 20 — Improper or off tracking

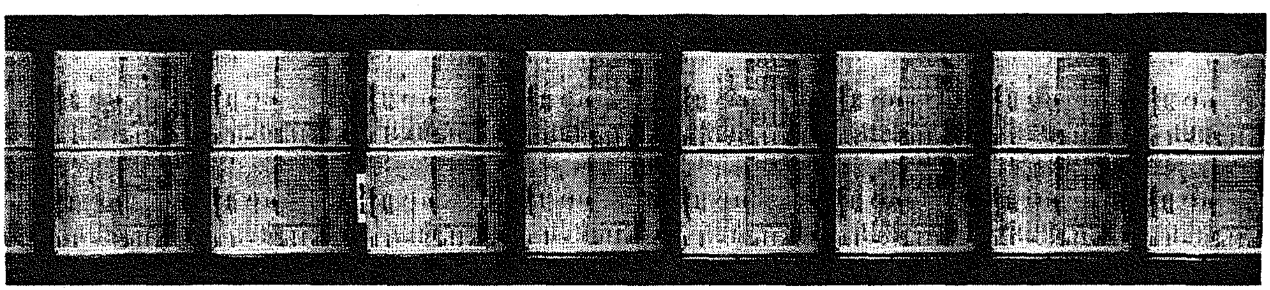


Figure 21 — Out of focus

12.3.19.4 Vesicular

The images are too dark, *D*min remains normal, and with gross overexposure the film has a rough surface and discoloration. Probable causes include too-high light intensity, too-large aperture, or too-long exposure time.

12.3.20 Pressure marks

Silver films with this defect have an area of reduced or increased density in the processed film. Probable causes are excess pressure or abrading or striking of the emulsion. See figure 24.

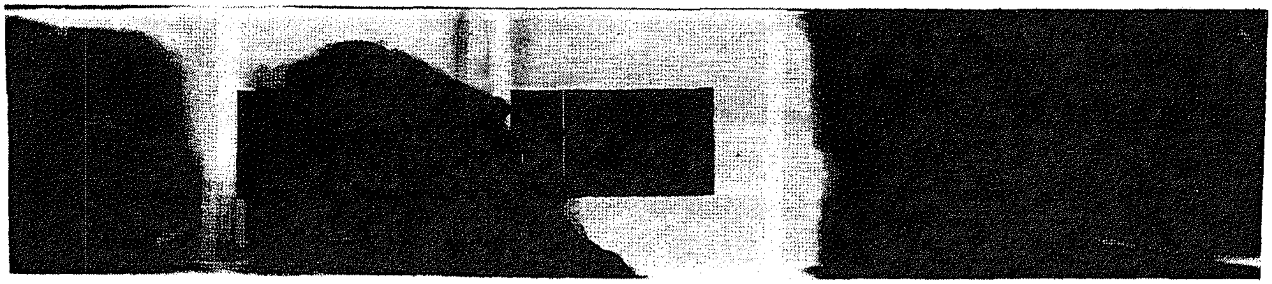
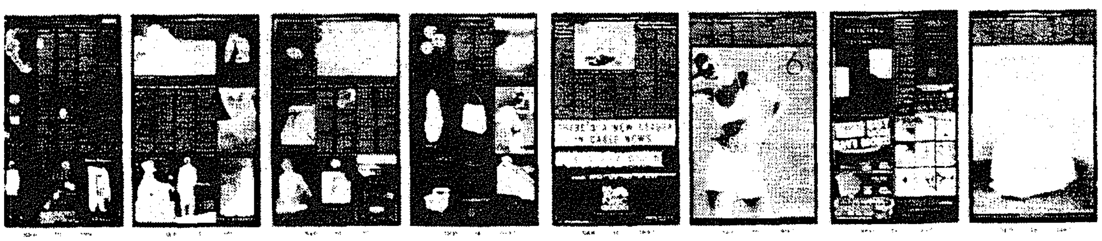


Figure 22 — Overdevelopment and chemical stains

Part a — Overexposure of sign-reversing film



Part b — Overexposure of sign-maintaining film

Figure 23 — Overexposure of sign-reversing film and sign-maintaining film

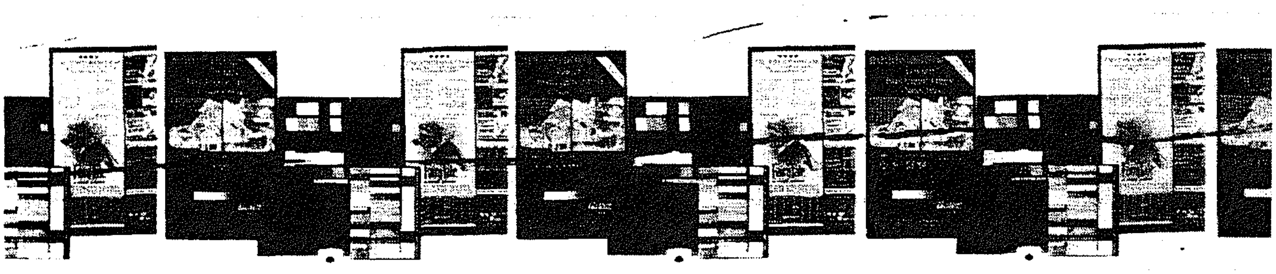


Figure 24 — Pressure marks

12.3.21 Resolution loss

There is always some loss in resolution when printing from one generation to another. If resolution targets are included on the master, the prints of them should be located and evaluated on a microscope. Maximum loss should not exceed one pattern per generation. At least three places should be checked on roll film (center and both edges). On card-to-card or card-to-roll duplicators, the four corners as well as the center should be checked. A loss of more than one pattern indicates a contact problem between the two light-sensitive surfaces.

12.3.22 Reticulation

With silver films, reticulation is a processing defect affecting the silver layers on photographic film, which shows an irregular surface because of the formation of small, irregular scaly patterns on drying. Sharp differences in the temperature or pH of successive processing solutions are the usual causes of reticulation.

12.3.23 Scratch (base)

This refers to a light- or dark-appearing line caused by damage to the base side of the film. It is usually caused by faulty, misaligned equipment or improper handling. Normally, image legibility is affected but not impaired.

12.3.24 Scratch (emulsion)

This refers to a light-or dark-appearing line caused by damage to the emulsion side of the film. It is usually caused by faulty, misaligned equipment or improper handling. (See figure 25.)

If the scratch passes through the image area, it may obliterate that portion of the image and will impair legibility. A sharp object or particle of grit can cause this defect. If the damage is deep enough so as to penetrate the emulsion layer, silver is removed and the image is altered. Many finer, shallower base and emulsion scratches neither show up objectionably on a microfilm reader nor duplicate through to successive generations or paper prints.

12.3.25 Static marks

These spots or streaks are produced on microfilm by the discharge of static electricity. Static electricity is generated in the film by means of friction. Such marks are made visible by developing (see figure 26).

Several distinctly shaped fog patterns can occur:

— The fog is caused by the blue light given off from the static discharge spark;

— Some marks are shaped like tree root systems, while others are round and strung out like a string of pearls.

In general, higher humidity levels help counteract the problem. Excessive static buildup may be caused by the following:

— cool and very dry (10 % to 20 % RH) ambient conditions;

— film with very low moisture content;

— excessive friction on a printer or processor;

— tightly wound film being unwound rapidly;

— extremely high-speed unwinding.

Static eliminators may be beneficial.

12.3.26 Light or dark streaks

This defect refers to film with a streak running lengthwise. It can be light or dark, depending on the generation and type of film. The streaks are usually caused by

— obstruction (film chips, hair, dust, etc.) in the printer lamphouse;

— a damaged aperture plate or mask in the printer;

— an emulsion coating defect;

— printing of a streak into the master.

12.3.27 Underdevelopment of a sign-reversing film

With silver, the images are too light on the microfilm. This defect is caused by insufficient development resulting from development for too short a time, use of a weakened developer, or too low a temperature maintenance. For diazo film, the images are too light. Probable causes are

— developing for too short a time;

— using insufficient ammonia;

— maintaining the heat in the developing chamber too low;

— using an improper type of ammonia.

For vesicular film, the images are too light. Probable causes are developing for too short a time or maintaining too low a temperature. (See figure 27.)

12.3.28 Underexposure

12.3.28.1 Silver gelatin, sign reversing (image change)

The images are too light on the microfilm, but the light struck areas at the beginning and end of the roll appear at high density. Probable causes include too-low light intensity, too-small aperture opening, too-short exposure time, or improper response of exposure-control device. (See figure 27.)

12.3.28.2 Silver, sign maintaining (direct image)

The images are too dark on the microfilm, but the light-struck areas at the beginning and end of the roll appear clear. Probable causes include too-low light intensity, too-small aperture opening, too-short exposure time, or improper response of exposure-control device.

12.3.28.3 Diazo

The images are too dark on the microfilm. Probable causes include too-low light intensity (bulbs defective or aged), too-small aperture opening, too-short exposure time, or equipment malfunction.

12.3.28.4 Vesicular — Negative-appearing

The line images are blooming (lack sharpness and definition); for example, the letter "e" fills in. Probable causes include too-low light intensity (bulb defective or aged), too-small aperture opening, or too-short exposure time.

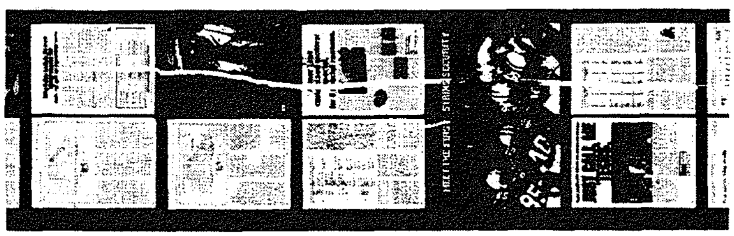


Figure 25 — Scratch (emulsion)

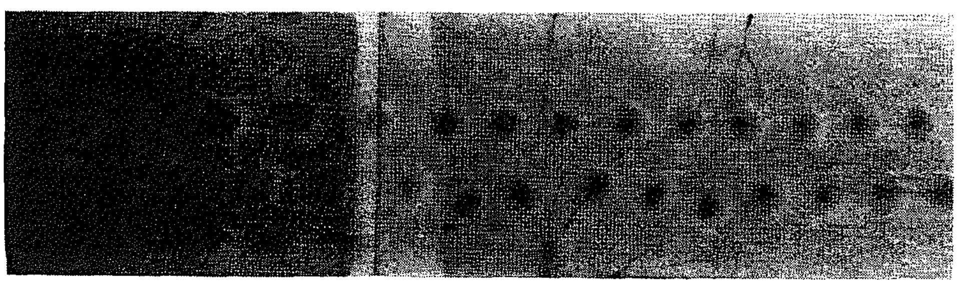


Figure 26 — Static marks

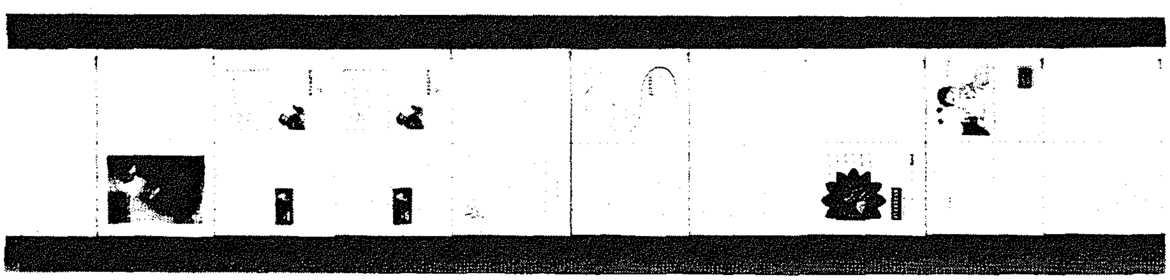


Figure 27 — Underdevelopment or underexposure of a sign-reversing film

12.3.29 Washboard

This defect appears as alternate bands of varying density across die width of the film. Probable causes include fluctuating illumination, faulty film transport, or out-of-synchronization master film and duplicate film transports.

12.3.30 Water spots

This defect entails deformation of the silver layer in an irregular spot pattern. Probable causes include inadequate squeegeeing of water (which leaves drops on the surface during drying) or residue from materials in the wash water. (A wetting agent added to the final wash could help reduce this condition.)

This defect also refers to film with whitish/brown spots normally caused by incomplete removal of wash water droplets. Water, unless it is deionized or distilled, contains minerals. When the droplet evaporates the minerals are left behind in the form of a spot. A surfactant bath (Photo-flo™ or the equivalent) just before the drying cabinet helps eliminate such spots.

13 Permanence of microfilm

13.1 Diazo microfilms — Adequate development

Just as with vesicular films, the key to ensuring the keeping qualities of diazo film is complete development. (See 10.2, methods A and B, for the correct procedures for determining complete development.)

13.2 Vesicular microfilms — Adequate development

The key to ensuring the keeping quality of vesicular films is to make certain the film has been fully developed and cleared. The best test for this is to hold a piece of exposed, processed film up to overhead light. If the film appears neutral in color, it has been fully developed. If it appears brownish, it has not been properly developed. Similarly, if the film appears greenish-yellow in the clear areas, it has not been totally cleared.

13.3 Silver microforms and residual thiosulfate tests

13.3.1 Permanent or long-term (LE 500) microfilms

In practice, processed silver microfilm to be used for long-term storage must not exceed 0.14 g/m^2 of residual thiosulfate. See ANSI/NAPM IT9.17.

13.3.2 Commercial Microfilm

In some applications the microfilm will be needed only for a limited period and is not classified as a permanent record. An allowable maximum limit of 0.040 g/m^2 of residual thiosulfate ion or a 0.08 density difference in the silver densitometric method is permitted.

13.3.3 Expendable Microfilm

If the film is to be used and discarded within a very short time, an exception can be made to the requirements in 13.3.1 and 13.3.2.

Annex A

(informative)

Sample inspection forms

(This annex is not a part of American National Standard for Information and Image Management — Standard Recommended Practice — Operational Procedures — Inspection and Quality Control of Duplicate Microforms of Documents and from COM — ANSI/AIIM MS43-1998.)

In figures A.1 through A.6, this annex includes the following sample inspection forms, which may be copied for production control: a processor control chart, a silver printer control chart, an inspection report form, a reprint request form, a microfiche scrap report sheet, and a film scrap report form.

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Processor Control Chart

Processor Number________ Processor Speed ________

Developer Temperature________ Developer Replenishment Rate____________

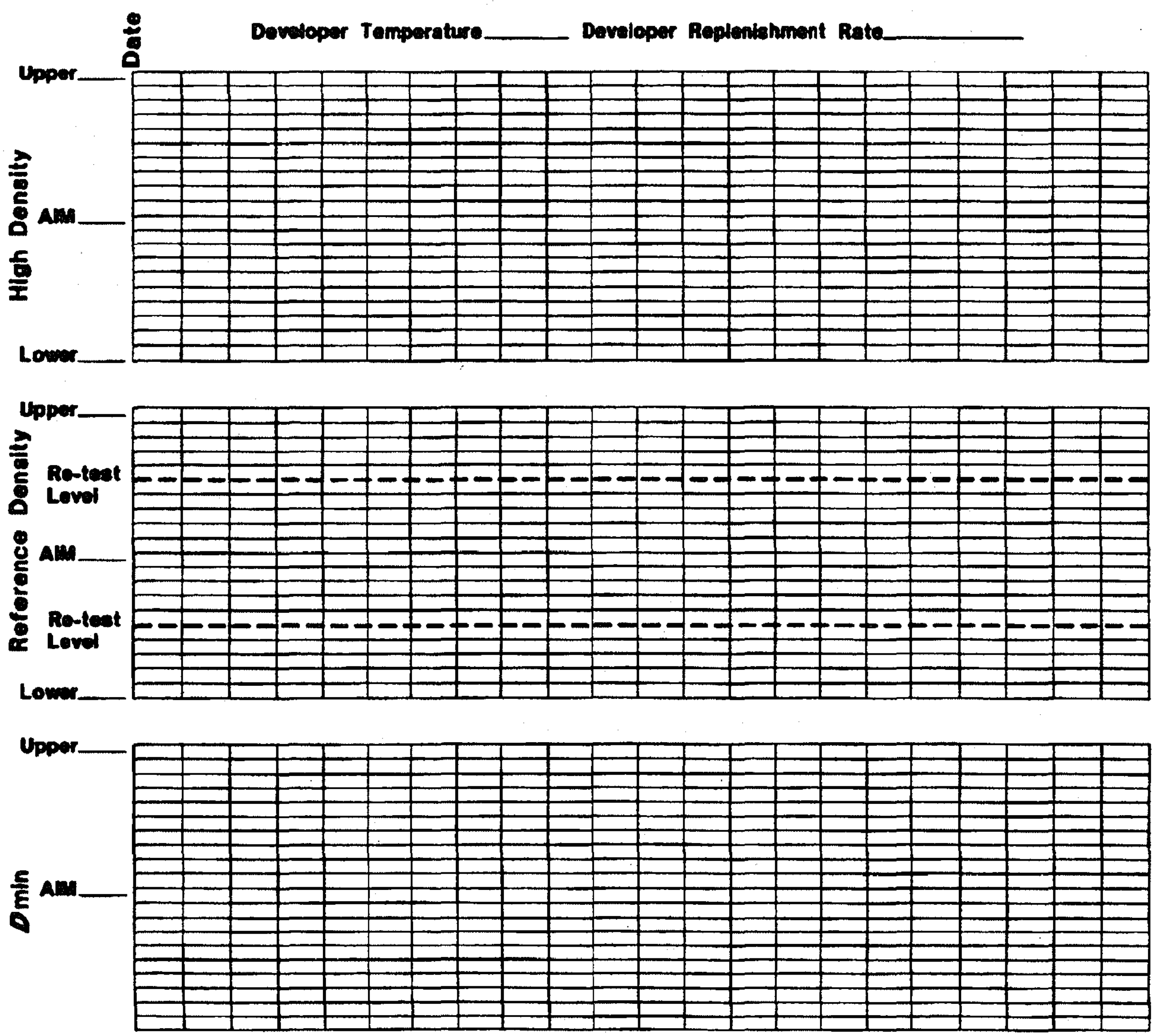

Figure A.1 — Processor control chart

Silver Printer Control Chart

Printer Number________________ Aim Density__________________ Step No.______________________

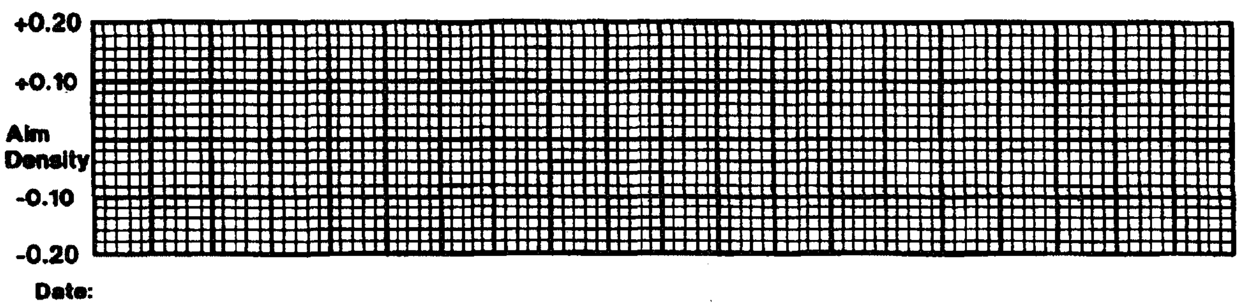

Figure A.2 — Silver printer control chart

INSPECTION REPORT FORM	INSPECTOR NAME		
	INSPECTOR NUMBER	DATE	WEEK NUMBER

ORDER TYPE	TRAVELER NUMBER	FILM RRQ'ST	PROG. NO.	TOTAL ROLLS	√	ROLL TO BE REPRINTED	REPRT. CODE	FILM & SET'NGS	SAME SET??	MACH. NO.	OPER. NO.	PRNT. DATE	OTHER COMMENTS

TOTAL INSPECTED:	TOTAL REPRINTED:	REPRINT CODES: 01 LIGHT, 02 DARK, 03 FOCUS, 04 TAPE, 05 SIZE, 06 NUMBER, 07 TYPE, 08 COPIES, 09 PRINTER, 10 BLURR, 11 MISTRACK, 12 PROC'SOR, 13 STOCK, 14 MISC., 15 OPERATOR, 16 PRE-PROG.	FOOTAGE SCRAPPED
		ORDER TYPES: MR FHC DUP RUSH GSC — MACHINE CODES: X1 X2 X3 X4 S1 S2 S3	

Figure A.3 — Inspection report form

REPRINT REQUEST FORM

Ticket Identification Request Number ___________/___________

Date ___________/_______/___________

____ Inspector ___________________
Number/Title

Printer Roll Number_____________Footage to be Discarded_______________Copies Needed________

Printed From: Direct Image Neg. Camera Neg. Duplicate Neg. Positive

Specific Location: ____

Defect Numbers (User assigns defects)

1	6	11	16	21	26	31
2	7	12	17	22	27	32
3	8	13	18	23	28	33
4	9	14	19	24	29	34
5	10	15	20	25	30	35

Defect Description ____

Figure A.4 — Reprint request form

MICROFICHE SCRAP REPORT SHEET

Employee ______________________________ Month of __________, 19____

Date	No. Fiche Rejected	Defect Number	Product Line	Comments

Defects

1. Dirt Spot Blocking Text
2. Dirt Throughout
3. Inaccurately Cut
4. Printed-in Scratches
5. Scratches
6. Processor Spots
7. Fingerprints
8. Black Line
9. Too Dark
10. Too Light
11. Thin Striping
12. Striping Runs Into Text
13. Row Overlap (out of focus)
14. Incorrect Master
15. Printed Through Base (out of focus)
16. Inadequate Contact on Printer
17. Inaccurate Master Alignment
18. Poor Quality Title Chararcters
19. Raw Stock Problem
20. Other ______________________________

(This sheet is to be turned in monthly.)

Figure A.5 — Microfiche scrap report sheet

FILM SCRAP REPORT FORM

Employee ______________________________ **Week of** ____/____ **19**____

Date	Footage Scrapped	Printer Number	Processor Number	Date Processed	Defect	Comments

Figure A.6 — Film scrap report form

Annex B

(informative)

Other resources

(This annex is not a part of *American National Standard for Information and Image Management — Standard Recommended Practice — Operational Procedures — Inspection and Quality Control of Duplicate Microforms of Documents and From COM* — ANSI/AIIM MS43-1998.)

The tools listed in this annex can be useful to the producers and users of duplicate microfilms:

— microfiche grid gauge with 98 frame 24:1 reduction;

— microfiche grid gauge with 270 frame 48:1 reduction;

— ANSI/ISO 3334-1991;

— SMPTE Test Film I6RT made according to SMPTE RP 20-R1975.

Publications and tools referenced in this document can be obtained from the following organizations:

— American National Standards Institute
Attn: Sales Department
1430 Broadway
New York, New York 10018;

— Association for Information & Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910-5603;

— National Institute of Standards & Technology (NIST, formerly NBS)
Office of Standard Reference Materials
Room B-3II Chemistry Building
Gaithersburg, Maryland 20899;

— Canadian General Standards
c/o Supply and Services Canada Place du Portage, Phase III
11 Laurier Street
Hall, Quebec K1A 0SS
CANADA;

— Society of Motion Picture and Television Engineers
862 Scarsdale Avenue
Scarsdale, New York 10583;

— Society of Photographic Scientists and Engineers
7003 Kilworth Lane
Springfield, Virginia 22151.