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ANSI/AIIM MS23-1998

STANDARD

Standard Recommended Practice—Production, Inspection, and Quality Assurance of First-Generation, Silver Microforms of Documents

ANSI/AIIM MS23-1998

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ANSI/AIIM MS23-1998

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Standard for Information and Image Management —

Standard Recommended Practice — Production, Inspection, and Quality Assurance of First-Generation, Silver Microforms of Documents

Association for Information and Image Management International

Abstract:
This document identifies and discusses the qualitative characteristics of first-generation silver gelatin microforms and the methods to attain, maintain, and measure levels of quality. The scope of this document excludes COM, updateable, color, and thermally processed microforms.

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Foreword

(This foreword is not part of the American National Standard for Information and Image Management ANSI/AIIM MS23-1998 — Standard Recommended Practice — Production, Inspection, and Quality Assurance of First-Generation, Silver Microforms of Documents.)

The original ANSI/AIIM MS23-1981 was a combination and a revision of the two National Micrographics Association (NMA) Recommended Practices: *Operational Procedures for the Production of Microforms* — NMA MS110-1974; and *Inspection and Quality Control of First-generation Silver-Halide Microfilm* — NMA MS104-1972. ANSI/AIIM MS23-1983 updated the 1981 version, and the 1991 revision is the result of the most recent review process. In 1993, the AIIM Quality Control Committee, C10, decided to completely redesign MS23 into a document that was more tutorial in nature. Throughout the document, references will be made to specific and appropriate standards. This revision results from a reexamination of the purpose, scope, and content of the previous standard with a view towards providing technical guidance in the identification, measurement, and evaluation of quality levels in first-generation silver microforms. The developers of this revision seek to emphasize that overall quality of a microform product involves many factors. The document discusses these factors, identifies quality procedures, and provides a means to measure the end product in terms of its suitability to serve an identified purpose. The flowchart in (informative) annex A lists many of the essential factors that are necessary to develop and maintain a successful micrographics operation for its intended purposes. Certain international, federal, state, and local regulations may require compliance with this document.

Many specific uses of microfilm, especially those that involve the microfilming of poor-contrast documents or image digitization, might require higher levels of quality than are indicated in this standard.

However, certain minimum standards should be maintained to ensure that microfilm quality is adequate for general use. This document identifies minimum quality requirements suitable for most source documents. (Technical specifications, quality levels, targeting requirements, and formatting requirements for microfilm to be scanned or digitized can be found in preservation microfilming documents published by the American Library Association and The Research Libraries Group.)

Blank forms for use during inspection are included in (informative) annex B and may be copied and used.

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

At the time this recommended practice was approved, the Standards Board of the Association for Information and Image Management International had the following members:

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Herbert White, II	LDS Church Family History

The AIIM C10 Document Microfilm Quality and Control Standards Committee had the following members at the time it processed and approved this standard.

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Robert M. Saholsky	U.S. Government Printing Office
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Mike VanDamme	Fuji Photo Film USA Inc.
Herbert J. White, II	Genealogical Society of Utah

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 MS23-1998

1 Purpose and scope

This document identifies and discusses the qualitative characteristics of first-generation silver gelatin microforms and the methods to attain, maintain, and measure levels of quality. The scope of this document excludes COM, updateable, color, and thermally processed microforms.

2 References

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

2.1 Referenced international standards

ISO 3334:1989 (ANSI/AIIM MS51:1991), *Micrographics — ISO resolution test chart No. 2 — Description and use.*

ISO 6196-1:1993, *Micrographics — Vocabulary — Part 01: General terms.*

ISO 6196-2:1993, *Micrographics — Vocabulary — Part 02: Image positions and methods of recording.*

ISO 6196-3:1997, *Micrographics — Vocabulary — Part 03: Film processing.*

ISO 6196-4:1987, *Micrographics — Vocabulary — Part 04: Materials and packaging.*

ISO 6196-5:1987, *Micrographics — Vocabulary — Part 05: Quality of images, legibility, inspection.*

ISO 6196-6:1992, *Micrographics — Vocabulary — Part 06: Equipment.*

ISO 6196-7:1992, *Micrographics — Vocabulary — Part 07: Computer micrographics.*

ISO/FDIS 6196-8, *Micrographics — Vocabulary — Part 8: Use.*

ANSI/ISO 417:1993 (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/ISO 10602:1995 (ANSI/NAPM IT9.1:1996), *Photography — Processed silver-gelatin type black-and-white film — Specifications for stability.*

2.2 Referenced American National Standards

ANSI/AIIM MS5-1992, *Micrographic Microfiche.*

ANSI/AIIM MS8-1988, *Document Mark (Blip) Used in Image Mark Retrieval Systems.*

ANSI/AIIM MS11-1987 (R1993), *Information and Image Management -- Microfilm Jackets.*

ANSI/AIIM MS14-1996, *Specifications for 16mm and 35mm Roll Microfilm.*

ANSI/AIIM MS15-1990, *Dimensions and Operational Constraints for Single-Core Cartridge for 16-mm Processed Microfilm.*

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

ANSI/AIIM MS18-1992, *Splices for imaged film — Dimensions and operational constraints.*

ANSI/AIIM MS24-1996, *Test Target for Use in Microrecording Engineering Graphics on 35 mm Microfilm.*

ANSI/AIIM MS26-1990, *35 mm planetary cameras (top light) — Procedures for determining illumination uniformity of microfilming engineering drawings.*

ANSI/AIIM MS32-1996, *Microrecording of engineering source documents on 35 mm microfilm.*

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

ANSI/AIIM MS35-1990, *Recommended practice for the requirements and characteristics of original documents that may be microfilmed.*

ANSI/AIIM MS41-1996, *Dimensions of unitized microfilm carriers and apertures (aperture, camera, copy and image cards).*

ANSI/AIIM MS43-1997, *Operational Procedures — Inspection and Quality Control of Duplicate Microforms of Documents and from COM.*

ANSI/AIIM MS45-1990, *Recommended practice for inspection of stored silver gelatin microforms for evidence of deterioration.*

ANSI/AIIM TR2-1992, *Glossary of imaging technology.*

ANSI/AIIM TR2-S1-1997, *Glossary of Imaging Technology — Supplement No. 1.*

ANSI IT9.2-1991, *Imaging Media - Photographic Processed Films, Plates, and Papers - Filing Enclosures and Storage Containers.*

ANSI/NAPM IT9.11:1993, *Imaging media — Processed safety photographic films — Storage.*

ANSI/NAPM IT9.15:1997 (ANSI/ISO 12206-1995), *Imaging media (Photography) — Methods for the evaluation of the effectiveness of chemical conversion of silver images against oxidation.*

ANSI/NAPM IT9.16:1993, *Imaging media — Photographic activity test.*

ANSI/NISO Z39.32-1996, *Information on Microfiche Headers.*

2.3 Referenced publications

American Library Association Preservation Microfilming Target Packet.

The Research Libraries Group Preservation Handbook.

The Research Libraries Group Archives Microfilming Manual and Preservation Microfilming.

AIIM Publication D021, *Preservation of Safety Film.*

AIIM Special Interest Package #34, *Microspots and Aging Blemishes.*

Kodak Pamphlet D-17, *Control Procedures in Microfilm Processing.*[1)]

3 Definitions

Definitions that are applicable to this document can be found in ANSI/AIIM TR2, ANSI/AIIM TR2-S1, and ISO 6196. If the definition of a term in the ANSI publications disagrees with the definition of the term in the ISO publication, the ANSI definition takes precedence.

4 System design considerations

4.1 Purposes of microfilming

The purposes of microfilming are quite varied and include the following:

- to aid in the preservation of information;
- to provide ready access to information;
- to reproduce copies of information documents;
- to increase distribution of such documents;
- to provide a source of image digitization;
- to provide a research data base;
- to provide for information storage;
- to simplify and expedite information retrieval;
- to reduce storage requirements;
- to maintain file integrity.

[1)] Documents with similar procedures may be used instead.

4.2 End-use

The use to which microfilm will be put strongly influences several major factors of overall system design. Factors that can have a profound effect on whether the microfilm will be capable of fulfilling its intended end-use include the following:

- — image size;
- — image placement and format;
- — reduction ratio;
- — image contrast (background density and text density);
- — density uniformity;
- — film size;
- — polarity;
- — resolving power;
- — film type;
- — frame positioning;
- — processing and storage conditions.

4.3 Life expectancy

At one time, film life was divided into two categories, archival and non-archival. The term "archival" was used to mean *forever*, and "non-archival" was used to mean *something short of forever*. A more meaningful designation, "life expectancy", often shown as "LE", has been devised and specifically refers to the number of years that filmed information can be retrieved under a certain set of manufacturing, processing, and storage conditions. At present, only properly processed and correctly stored silver halide film on polyester base has an LE rating of 500 years (LE 500), whereas acetate-based silver halide film can have LE ratings of 100 years. A responsible decision-maker will use the desired LE rating as a critical factor in selecting system characteristics. International, federal, state, and local regulations as well as commercial contracts and specifications may dictate that specific LE requirements are met.

4.4 Number of generations

Each successive film copy of a document, beginning with the film produced in the camera, is referred to as a specific generation. For example, the camera master is referred to as the first generation. A copy made directly from the camera master is a second generation. A copy made from the second generation is a third generation, and the like. The film produced in a camera is given any of several names: camera master, camera negative, original master, camera original, original camera negative, and preservation master. Frequently this first-generation film is stored as a master from which copies are produced. Although maximum protection must be given the first-generation master, a small number of copies (fewer than five copies) may be produced from it. If a large number of copies are needed, then an intermediate (second-generation) version should be produced. Multiple copies can then be printed from this second-generation printing negative. However, as the number of generations increases, image quality deteriorates and contrast increases rapidly. Producing more than four generations proves neither practical nor desirable. As the number of generations to be produced increases, overall quality level of the camera master must increase.

Regardless of polarity, with each generation the side of the film through which the image can be properly read (right-reading) alternates. See figure 1. Images in the first generation are readable through the shiny base side of the film. The second generation reads correctly through the dull emulsion side of the film. The third generation can be read through the base side. Correct identification of emulsion sides is critical when succeeding generations are produced because proper duplication is only possible with emulsion-to-emulsion contact.

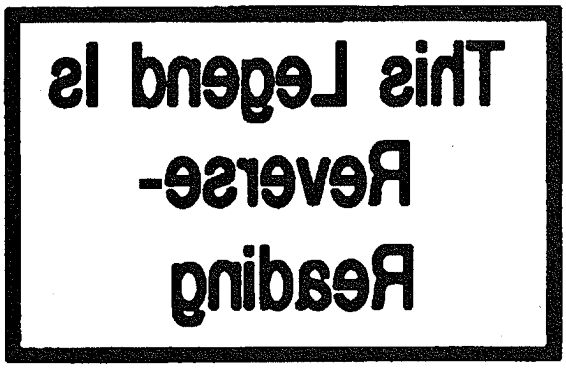
4.4.1 Film base appearance

The relatively thick, transparent film base serves as a carrier or support for the extremely thin silver-bearing image (emulsion) layer. The base appears shiny when viewed by reflected light.

4.4.2 Film emulsion appearance

The extremely thin emulsion layer, composed primarily of gelatin and silver, has a rough, matte surface and appears dull when viewed by reflected light.

Example of right-reading



Example of reverse-reading

Figure 1 — Examples of right- and reverse-reading

4.5 Image polarity

Negative-appearing images contain clear characters on dark backgrounds, and positive-appearing images contain dark characters on clear backgrounds. See figure 2.

Negative images look cleaner because foreign matter (such as dust, fingerprints, and the like) and scratches are less evident. Negative images, which generate less optical flare, tend to have higher contrast, cause less eyestrain, and generally produce higher-quality reader-printer prints than positive images.

Positive polarity has several advantages:
- images look like source documents;
- pictures have more tonal detail;
- more silver is available for recovery;
- film remains cooler in the viewer gate of the reader.

Disadvantages include that greater eyestrain is possible and that foreign matter and scratches show more readily.

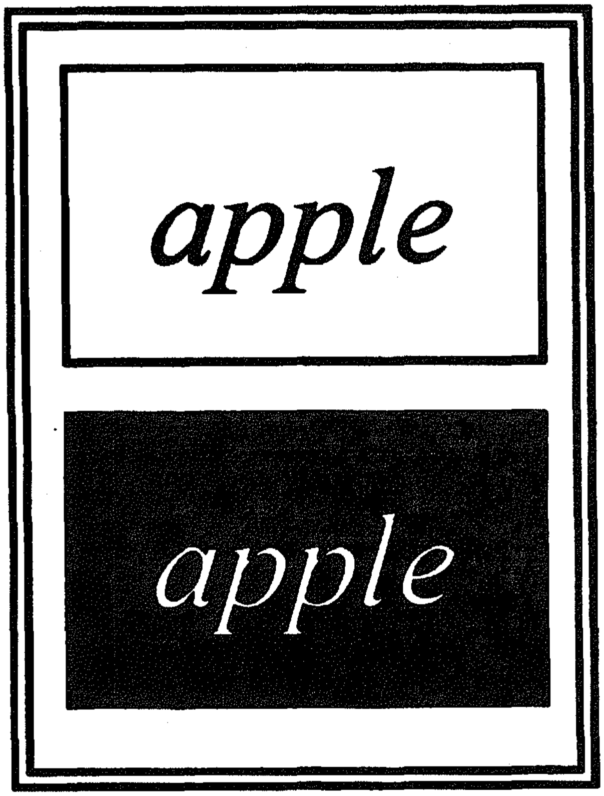
Negative-appearing masters, when printed onto reversal film stock, produce positive-appearing duplicates. Likewise, when printed onto non-reversal stock, negative masters produce negative duplicates.

The polarity scheme, number of generations, and reversal or non-reversal film types to be used should be determined before duplication. It is generally advisable during the duplication process to maintain one polarity until a final copy is produced. Switching polarity of generations back and forth between negative and positive causes the contrast level to increase tremendously. For example, if a high number of negative copies is required, and the second generation printing master has positive polarity, the final negative copy will have extremely high contrast. High densities (shadow detail) contained in the positive images are converted and compressed into clear areas on the negative copy. Although this might be helpful for documents that contain only textual information, it is highly undesirable for high-contrast documents which contain graphs, charts, photographs, halftones, faint text, or other shades of gray.

Maintaining negative polarity during duplication reduces interferences due to foreign material (such as fingerprints, dust, and the like) on the film surface.

4.6 Audience

The end user, at times, plays an important part in determining the quality of the microfilm and what type and level of defects will be tolerated. If the user is fluent in the language contained on the microfilm, he or she might be able to "read" by inference if several characters of a word or words are missing. A less skilled reader might rely heavily on all characters being perfectly formed and having adequate contrast. If the information is numeric, then all data must be present and legible.



Positive-appearing image

Negative-appearing image

Figure 2 — Examples of positive and negative image polarity

4.7 Level of quality desired

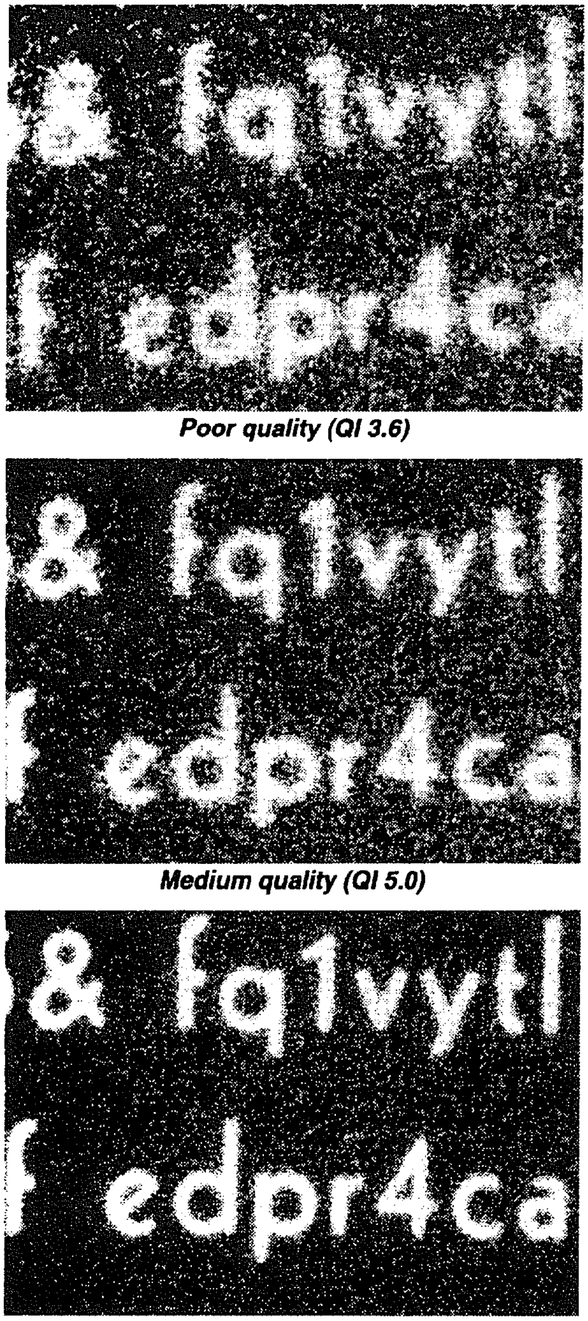
Microfilm quality should not be based on available equipment or lowest cost but on legal requirements, user needs, and data-retention requirements. Ignoring necessary quality requirements in order to cut costs is not a viable alternative and can result in legal, user, and retention problems. Original document quality also dictates necessary production criteria and system design necessary to accurately capture the data. In general, the custodian of the records must determine the quality level and degree of inspection necessary to ensure that acceptable microfilm quality levels have been met. If the microfilm copy serves as an original master in a system where several subsequent generations will be produced or when filming is intended to preserve the source document information, extremely high-quality products are essential. Conversely, if the microfilm is being produced to serve as a security backup and will be rarely if ever used or viewed, then image quality and overall performance might be less critical. See figure 3.

The type of camera selected for a specific project can affect several quality-related factors. Planetary cameras usually offer greater control than rotary cameras over such variables as resolution, alignment, and exposure control. Camera selection is first based on quality requirements and then based on microform and production throughput. See 6.1.1.1 and 6.1.1.2 for more information about planetary type and flow/rotary types of cameras.

4.8 Type of documents

When planning a microfilming project, all of the following should be considered:

- the overall size, shape, and physical condition of a document;
- paper opacity;
- ink opacity and color;
- paper reflectivity and color;
- uniformity of overall contrast;
- type font and size;
- width of thinnest lines.



Poor quality (QI 3.6)

Medium quality (QI 5.0)

High quality (QI 8.0)

Figure 3 — Levels of microimage quality

See ANSI/AIIM MS35 for more information about the requirements and characteristics of documents to be microfilmed. Documents that are bound and must remain so during microfilming present yet another set of conditions (such as reflections from curved surfaces and shadows in the gutter of the binding) that will affect filming decisions and procedures. If certain documents are not suitable for microfilming, a decision not to film might be appropriate. Also, different camera-lighting angles as well as polarizing filters might be necessary to minimize shadows and reflections. See 5.5 for information about bound documents versus loose documents and 5.6 for information about the removal of bindings. Generally, unbound documents that consist of dense black ink on very white paper with high opacity produce the most legible and reproducible microfilm images.

4.9 Density aim point

Modern panchromatic camera microfilms are capable of providing extremely high-quality images for a wide variety of documents. Documents of various contrast levels and color schemes can be successfully recorded by attaining a proper density level (level of contrast between text and background). Proper density levels are achieved by varying the amount of exposure used during the filming step. Depending on camera design, this density level can require a change in lamp voltage, exposure time, aperture setting, or a combination of the three. Documents with poor contrast require low densities; documents with good contrast can tolerate higher density levels. Therefore, it is necessary at the start of a microfilming project to determine density levels best suited for the documents being photographed. See figure 4 and table 1. Microfilm scanning systems can also affect the choice of background density. If the user accepts any density the respective imaging system is capable of delivering and is not controlling the final image contrast, too much variance for consistent image quality will result. If the user tries to cut costs by disregarding the monitoring and control of exposing and processing steps, those cost savings are offset when the user attempts to compensate for fluctuations in the density and contrast of the images, especially when creating subsequent generations.

4.10 Targeting

A target is visual or readable information about the source documents that are being microfilmed and the conditions under which they are filmed. Because it is microfilmed with the documents, target data becomes an actual component of the film record itself. (See 8.3.4

for more information about targets.) Targeting should provide the following:

- bibliographic data about the filmed documents;
- technical data about the filming process;
- additional information about the filming project and producer of the film;
- an audit trail for legal purposes;
- instructions for the reader about the use of the microfilm.

More specifically, targets can enhance the microform product by providing the following information:

- file title;
- source document or reel title;
- reel contents;
- missing material;
- apparent missing material;
- imperfections;
- bibliographic/chronological breaks;
- library cataloging data;
- misnumbered pages;
- apparent errors;
- start or end of reel;
- retake targets;
- roll number;
- storage locations;
- holder of source documents;
- restriction notices;
- classification notices and declarations.

Targets can also be designed to provide technical information about the microfilming system (such as film make, film type, film emulsion batch, film lot number, film expiration date, camera's lighting balance, resolution, residual chemicals, reduction ratio, exposure level, and uniformity). Resolution test targets should be certified, the correct type, correctly located on the film, and correctly located within the frame. Decide which targets will be filmed before giving a file to the microphotographer for filming.

Targets should be designed to draw attention and be visually identifiable from the microfilmed documents. Targets can be classified by content, and they can be further divided into those read with the unaided eye (those that are eye-legible) and those read with magnification on a reader. Eye-legible targets should be composed of characters that will be at least 2 mm high on the finished microfilm product. To determine original character height, multiply the reduction ratio to be used by 2 mm. For example, an eye-legible target for use with documents to be reduced 24 times (1:24) should have characters that are at least 48 mm high (24 × 2 mm). In practice, 60-point type is eye-legible at lower reduction ratios (1:8 to 1:14). The production of eye-legible targets is simplified by the use of desktop publishing software and a laser printer. Because such large targets contain little information, they are generally reserved for use at both ends of the reels, when the film can be viewed without a reader and when necessary to draw attention to specifics within the reel while using a reader.

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)

When necessary to include large quantities of information on a target, smaller type sizes should be used. A technique, however, should be devised for making the target visually unique compared to the source documents being microfilmed. Several possibilities are

— contrasting type size;
— smaller target sizes;
— contrasting or patterned backgrounds;
— patterned borders;
— reversing the polarity of text and background.

See *American Library Association Preservation Microfilming Target Packet, The Research Libraries Group Preservation Handbook,* and *The Research Libraries Group Archives Microfilming Manual and Preservation Microfilming* for more discussion on targeting. Information regarding a variety of pre-printed targets is readily available through such organizations as the American Library Association, AIIM International, The Research Libraries Group, and the Library of Congress.

See figure 5 for a typical targeting sequence.

4.11 Forms design

Forms designers should consider the recommendations found in ANSI/AIIM MS35 when designing forms and graphics for office documents that are to be microfilmed. Some elements of a document to consider are fonts, type sizes, print contrast, paper and ink color, opacity, and reflectivity.

4.12 Type of film

There is, at present, one category of microfilm suitable for microfilming traditional source documents. This film, which is capable of an LE 500-year rating, is polyester based and includes an anti-halation dye system to prevent light scattering and fogging. Cellulose acetate based microfilms can have an LE rating of 100 years but are not suitable for preservation (archival) purposes. See AIIM Publication D021, ANSI IT9.1, and ANSI IT9.11.

4.13 Image position

Images of documents can be positioned on film with the bottom edges of the documents perpendicular to the length of film; this is referred to as the "Vertical Format" ("Portrait", "A Format", or "Cine Format"). When the bottom edges of the documents are parallel to the length of film, the format is referred to as "Horizontal" ("Landscape", "B Format", or "Comic Format"). Generally the format chosen is based on

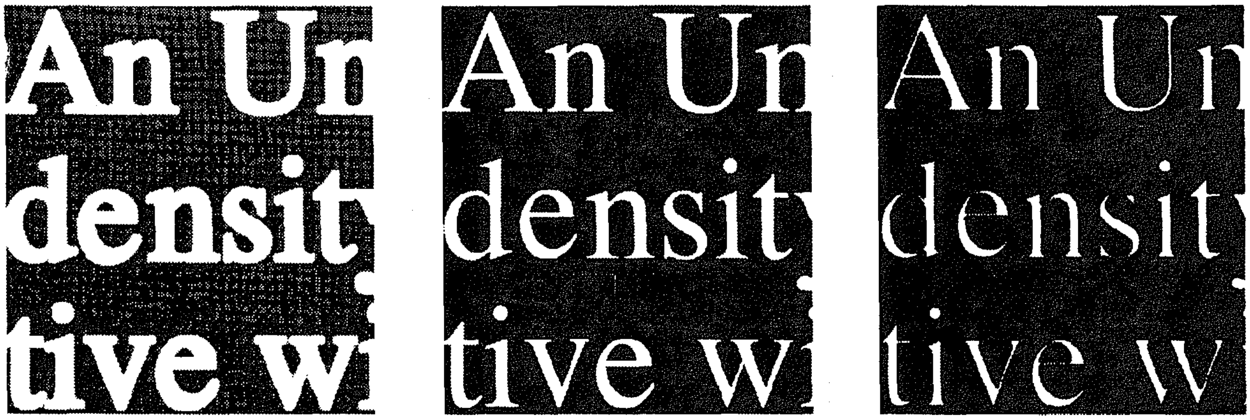
— optimizing film usage;
— rotational capabilities and screen size of the viewing equipment;
— document dimensions;
— desired reduction ratio;
— camera constraints;
— end-user convenience.

One advantage of Vertical Format is that scratches and gouges, which normally run parallel to the length of the film, can obliterate only a word or two within a sentence but not an entire sentence. See ANSI/AIIM MS14 for more information about image position. See figure 6.

4.14 Film size

Three film widths are in common use today: 16 mm, 35 mm, and 105 mm. The 16 mm film is generally used for commercial applications and loaded into plastic cartridges (see ANSI/AIIM MS15 and ANSI/AIIM MS16) for auto-threading convenience. Reduction ratios ranging from 1:24 to 1:50 are common. See ANSI/AIIM MS14.

The 35 mm film is normally wound onto open plastic reels and is ideally suited for serial publications (such as periodicals and newspapers); engineering drawings; and the preservation filming of manuscripts, journals, and books. See figure 7. Reduction ratios for these materials tend to be lower and are commonly in the 1:8 to 1:20 range. Most aperture cards are designed to accommodate images created on 35 mm microfilm. See ANSI/AIIM MS14 for more information about reduction ratios.



Underexposure
This segment was underexposed. Although transparent areas are clear, the dark areas have low density. A positive made from a negative of this type shows thickening of all detail.

Correct exposure
This segment was exposed correctly. The dark areas are adequately dense, and the transparent areas are adequately clear. Edges are sharp, and characters are true to the original.

Overexposure
This segment was overexposed. Dark areas are too dense, and density appears in some areas that should be clear. A positive made from a negative of this type shows loss of fine detail.

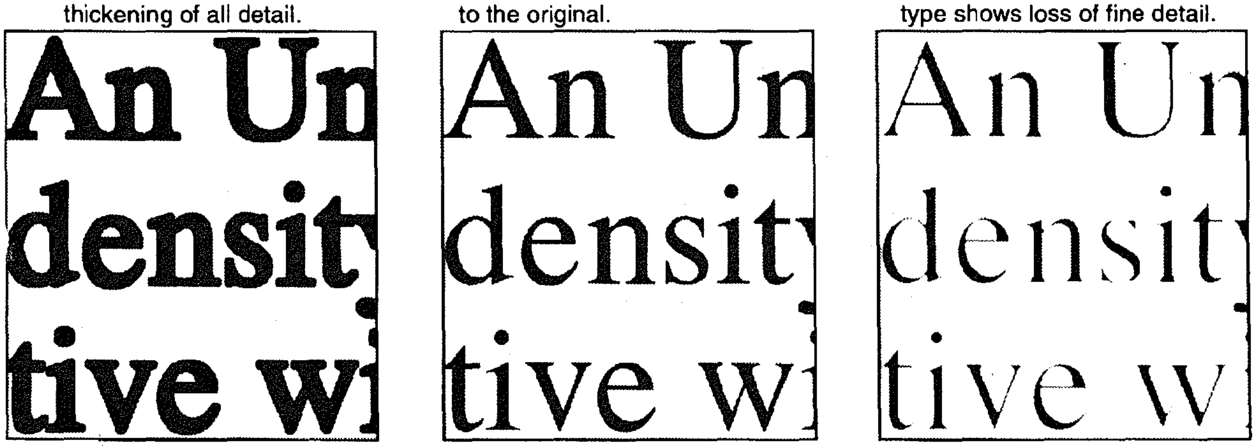


Figure 4 — Effects of underexposure and overexposure

The 105 mm roll-film stock is usually cut, which yields individual "cards" referred to as "microfiche". Although the standard number of frames on a microfiche is 98 (7 rows of 14 images plus a title area), up to several hundred, depending upon reduction ratio, can be contained on one fiche. Reduction ratios commonly range from 1:20 to 1:48. The microfiche format is ideally suited for non-serial publications, unitized documents, or monographs. Because minimal packaging is required, compact storage is possible. One major disadvantage of microfiche is the possibility of misfiling individual cards. Microfiche formats and dimensions are provided in ANSI/AIIM MS5.

4.15 Microfilm formats

4.15.1 Roll film

"Roll film" is commonly used to refer to long lengths (that is, 100 ft to 215 ft or 30.5 m to 65.5 m) of 16 mm and 35 mm microfilm. Roll films intended for viewing on a reader are normally wound onto inert plastic reels. Roll films intended for duplication are wound onto 2 in or 3 in diameter cores. Various cartridge systems are available for roll-film viewing. Some motorized readers permit rapid automatic or semi-automatic threading. Roll film is ideally suited for recording serial information (such as that in periodicals and newspapers).

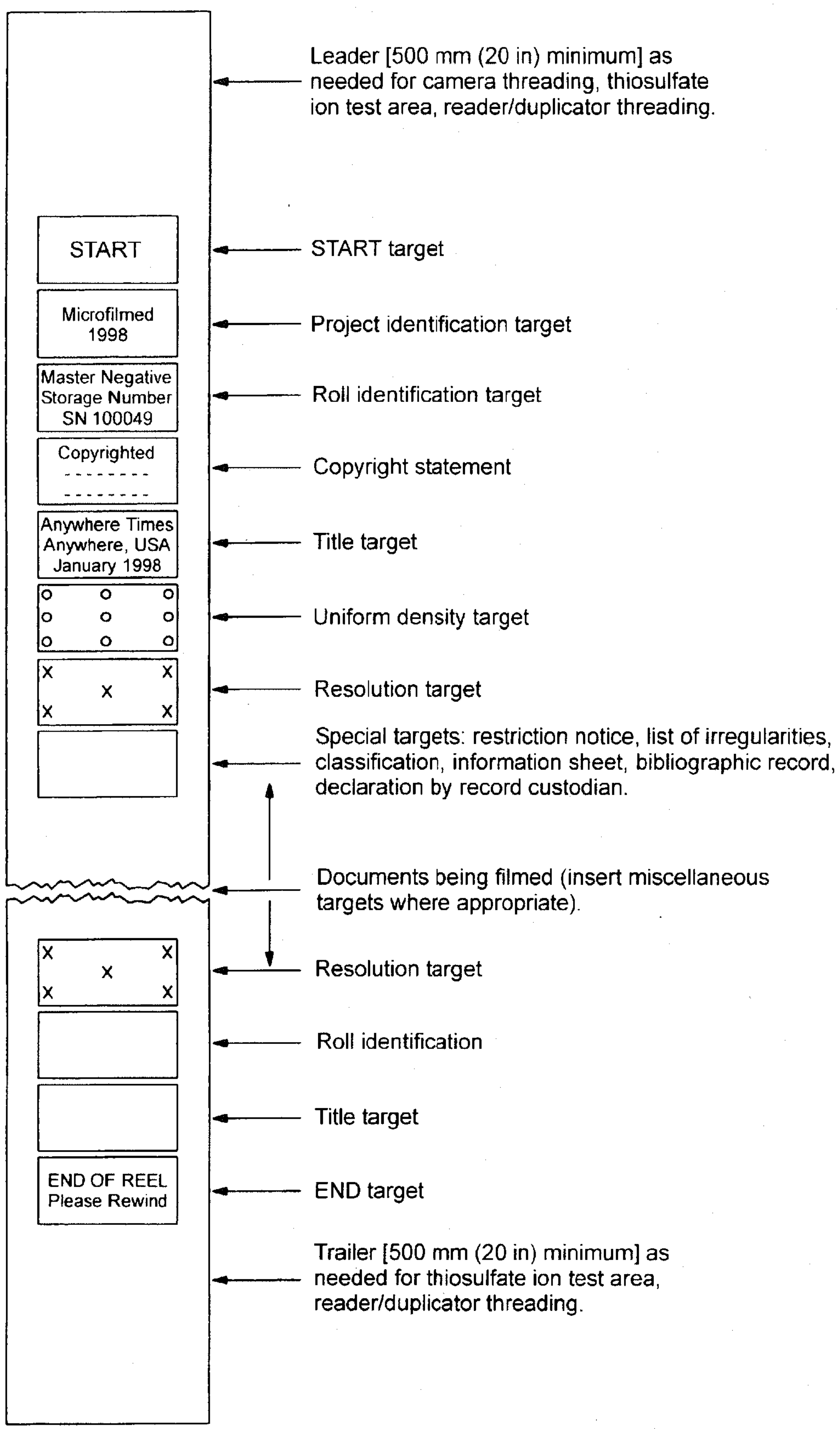
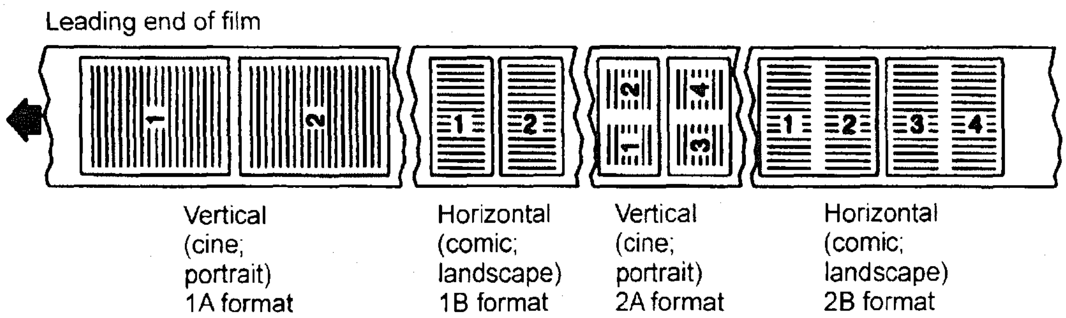
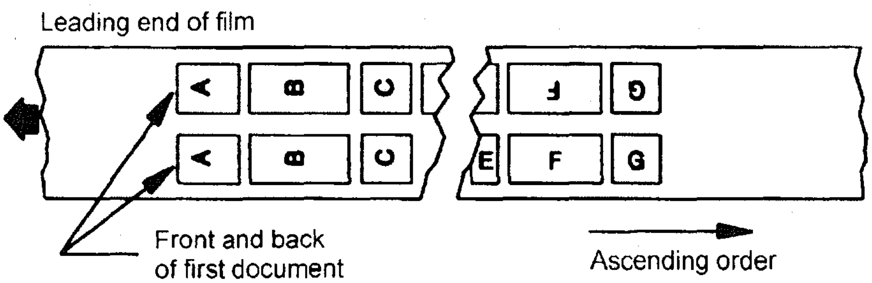


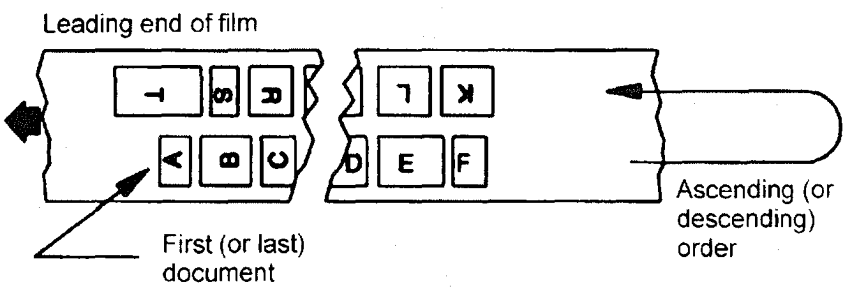
Figure 5 — Targeting sequence



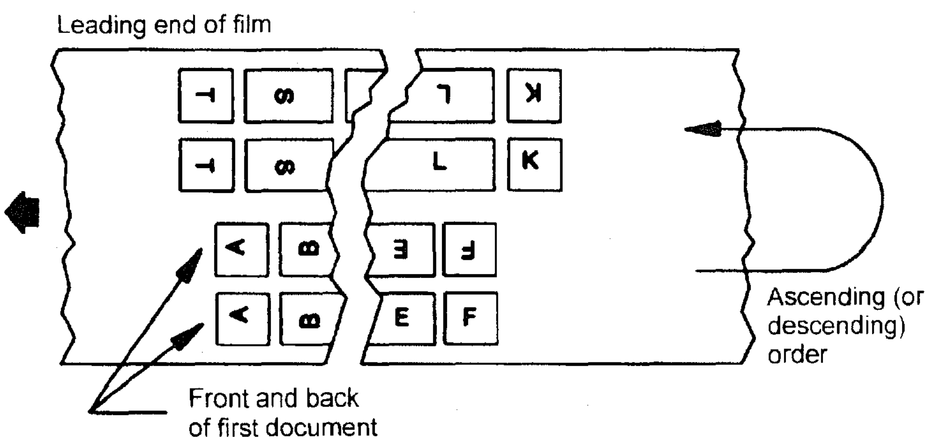
Simplex format



Duplex format

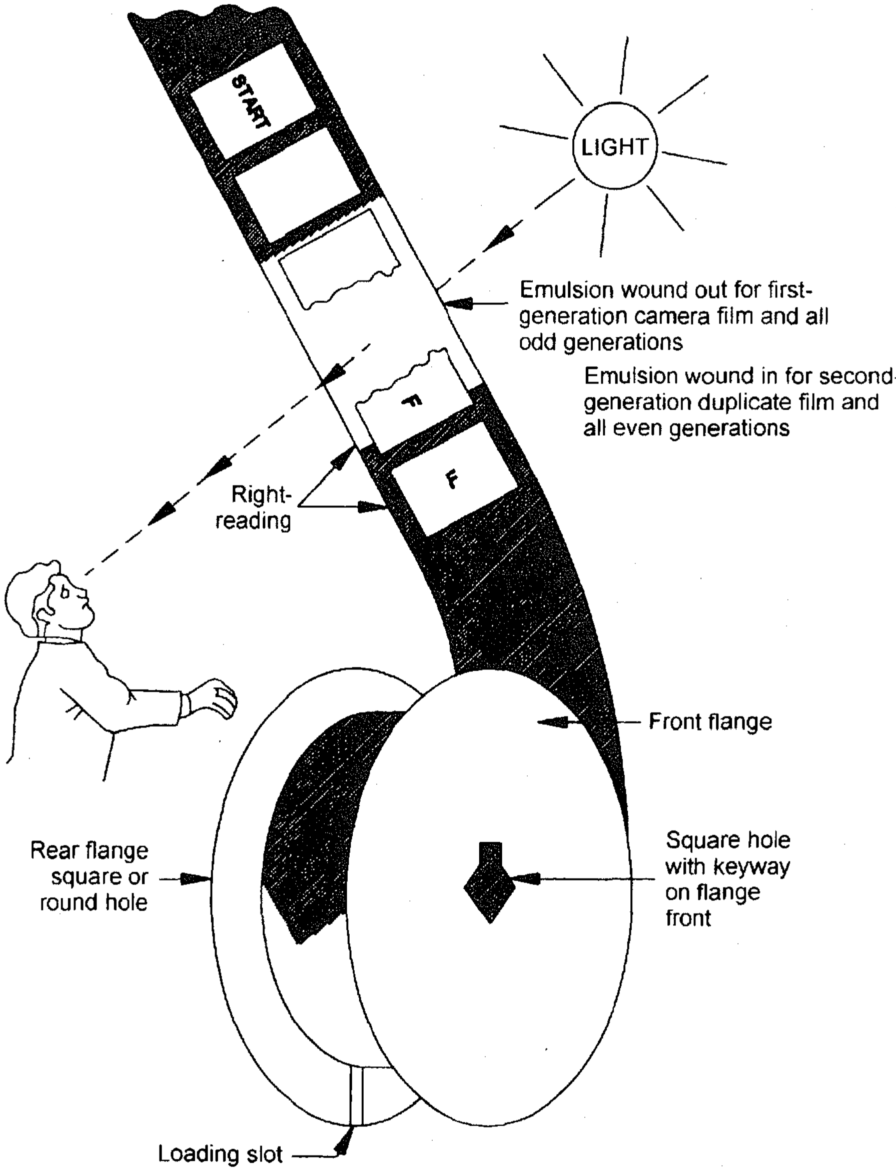


Duo format



Duo duplex format

Figure 6 — Roll-film formats



NOTE — Image is right-reading from position of observer as shown (all generations).

Figure 7 — Orientation of camera film images on the reel

Roll film is subject to more wear and abrasion than other formats because

- roll film is transported around and through a series of moveable or fixed objects on a reader;
- to view images on the second half of a film, a user must wind through the first half, increasing the likelihood of scratches or other abrasions.

4.15.2 Aperture cards

Heavy weight data-processing cards have an opening or window to accommodate single microimages cut from roll film. Older aperture card systems required that cards be punched and processed on electronic data-processing equipment (EDP). Today's mark-sensing bar codes and optical character recognition (OCR) systems are in common use and offer advantages over the obsolete "punch card" method. In some instances, the cards are labeled before the film is mounted to avoid film damage. Punching, printing, and sorting after mounting should be limited and done only on EDP equipment that is modified to minimize scratches to the film area.

Aperture cards in a variety of formats (including 105 mm × 148 mm microfiche size format) are available to accommodate both 16 mm and 35 mm film images. Microfiche formats permit the use of standard duplicators and allow for interfiling with other microfiche collections. See ANSI/AIIM MS32 and ANSI/AIIM MS41.

The orientation, location, and frame spacing (pulldown) of the images on a roll of microfilm must be correct and consistent if the film is to be cut and mounted in aperture cards. For example, frame size and tolerance for 35 mm film mounted in a MIL-D aperture card is 50.8 mm (2.00 in) + 1.5 mm (0.06 in) - 0.000 mm (0.00 in). See also ANSI/AIIM MS32. For other film sizes, see ANSI/AIIM MS41.

4.15.3 Microfiche

Microfiche can be produced by several methods. A step-and-repeat camera might be appropriate for high-volume applications requiring no revising or updating capabilities. These cameras use 105 mm roll or cut sheet film. The nominal size of the microfiche is 105 mm by 148 mm (ISO A6 sheet size). The film carrier correctly positions the film to expose individual frames and produces the desired number of rows and columns.

The strip-up process is used normally for those applications that require revision or updating capabilities and small volume applications. After the film is processed, it is slit to the required width and then cut into short strips. Images are arranged and registered into rows and columns. The strip ends are joined using a suitable polyester tape on jigs or fixtures that are designed specifically for this purpose. Both 16 mm and 35 mm film can be stripped up in this manner. The 16 mm film with images at a reduction ratio of 1:20 can be stripped up without slitting to produce a 60 frame microfiche. Both 16 mm and 35 mm film must be trimmed widthwise to form a film strip 12.5 mm wide to produce a 98 frame microfiche.

Two-step optical reformatting can be used to create microfiche. A high-quality optical printing system projects illuminated frames of first-generation film onto a receiving raw film stock. Images can be reduced and rotated to produce a variety of film formats. See ANSI/AIIM MS5 for more information about creating microfiche. See table 2.

Table 2 — Microfiche formats, document sizes, and reduction ratios

Format	Number of frames	Frame size	Columns × Rows	Document size	Nominal reduction	Reduction range/source documents
20/60	60	11.75 × 16.5	12 × 5	216 × 279 (8.5 × 11)	1:20	1:12 to 1:26
24/98	98	10.0 × 12.5	14 × 7	216 × 279 (8.5 × 11)	1:24	1:12 to 1:29
42/208	208	8.75 × 7	16 × 13	356 × 279 (14 × 11)	1:42	1:41 to 1:44
42/325	325	5.5 × 7	25 × 13	216 × 279 (8.5 × 11)	1:42	1:30 to 1:46
48/270	270	7.75 × 6.25	18 × 15	356 × 279 (14 × 11)	1:48	1:47 to 1:50
48/420	420	5 × 6.25	28 × 15	216 × 279 (8.5 × 11)	1:48	1:32 to 1:50

NOTES

1 Document sizes are given in millimeters and parenthetical inches.

2 The reduction ranges for a given microfiche format should be used to accommodate documents of sizes different from those listed for that format. For documents that do not conform to the size listed, microfilming at the lower reduction ranges can cause the information area to exceed the microfiche frame area.

3 The microfiche formats, shown in the "Format" column, are represented by two numbers that describe the type of microfiche by its nominal reduction and the number of microimage frames.

4.15.4 Jackets

Microfiche jackets provide a method for creating microfiche from short strips of 16 mm or 35 mm roll microfilm. Individual strips of image-bearing film are simply slipped into any or all of the channels, sleeves, or pockets on the jacket to form a matrix of images. These microfiche can be viewed directly or used as masters for creating subsequent copies. The two layers of transparent material that are fused together to form the jacket channels are of different thickness. (See 4.4 for more information about the number of generations.) The film must be loaded so that the emulsion side is facing the thinnest material. (See 4.4.2 for more information about the emulsion's appearance.) This method of loading permits making contact duplicates with minimal resolution loss. If the film is inadvertently loaded with the emulsion side towards the thicker support, the copies will have serious focus problems. Jackets are available in a wide range of sizes for 16 mm film, 35 mm film, or a combination of both. Various types and sizes are available to suit specific applications; however, the preferred, most common size is 105 mm by 148 mm. Jackets can be updated by simply adding or exchanging images. Jacket dimensions, operational constraints, and other general characteristics are found in ANSI/AIIM MS11. Production guidelines for image placement and other format recommendations are available in AIIM/AIIM MS14.

4.15.5 Scroll microfiche

For reasons of economy, microfiche are normally photographed and reproduced on raw film stock rolls of various lengths up to 1000 ft (305 m). Eventually these rolls are cut into individual cards for filing and viewing purposes. If a sequence or collection of microfiche is left in roll form and not cut, it is referred to as "scroll microfiche". A reader that transports rolls of 105 mm film must be used for viewing this format.

4.16 Reduction ratio

Reduction ratio is a numerical representation of the relationship between the size of the microfilm image and the size of the original from which it was made. It is normally expressed with the number "1" and a colon, as in "1:24".

The degree of reduction used must be chosen after carefully considering all the system requirements and the following factors:

- — size, line width, quality, and contrast of the alphanumeric characters being microfilmed;
- — size and shape of the original documents;
- — number of generations to be produced;
- — Quality Index requirements;
- — resolution capabilities of the camera and lens;
- — size of film being used;
- — magnification and image rotational capabilities of available viewing equipment;
- — size and shape of screen on viewer;
- — resolution and contrast characteristics of the film being used for duplicates.

When reduction ratio is the only variable, lower reduction ratios provide higher image quality, and greater amounts of film are used. Trade-offs exist between image quality, packing density, and film usage; but if image quality alone is considered, larger images are usually better. Further, a larger image is generally more tolerant of poor-quality original documents and microfilm system variables such as density fluctuations, camera vibrations, and resolution loss. Thus, all other things being equal, a lower reduction ratio (larger image) is preferable to a higher reduction ratio (smaller image). See ANSI/AIIM MS14.

4.17 Microfiche indexing

4.17.1 General

Locating a specific frame on a multi-image microfiche can be time consuming. Several indexing techniques have been devised to help the user quickly locate a desired image. It is important to consider the indexing and retrieval system to be used before preparing documents for conversion to microfiche. Targets or dividers must be placed in proper sequence, titles must be prepared, and automated indexes, if applicable, must be developed. General recommendations for the title (header) area and frame identification can be found in 4.17.2 of this document. Formats for microfiche can be found in table 2. Figure 8 shows a typical format for a 98 frame microfiche. Requirements for microimage and heading placement, pagination, cut marks, and sectionalized microfilming can be found in ANSI/AIIM MS5.

4.17.2 Title (header-area) contents

Title (header-area) contents include the following:

- — identification number;
- — alphanumeric characters;
- — machine readable codes;
- — sequencing multiple microfiche;
- — frame identification.

See ANSI/NISO Z39.32 for more information about microfiche headings.

4.17.2.1 Identification number

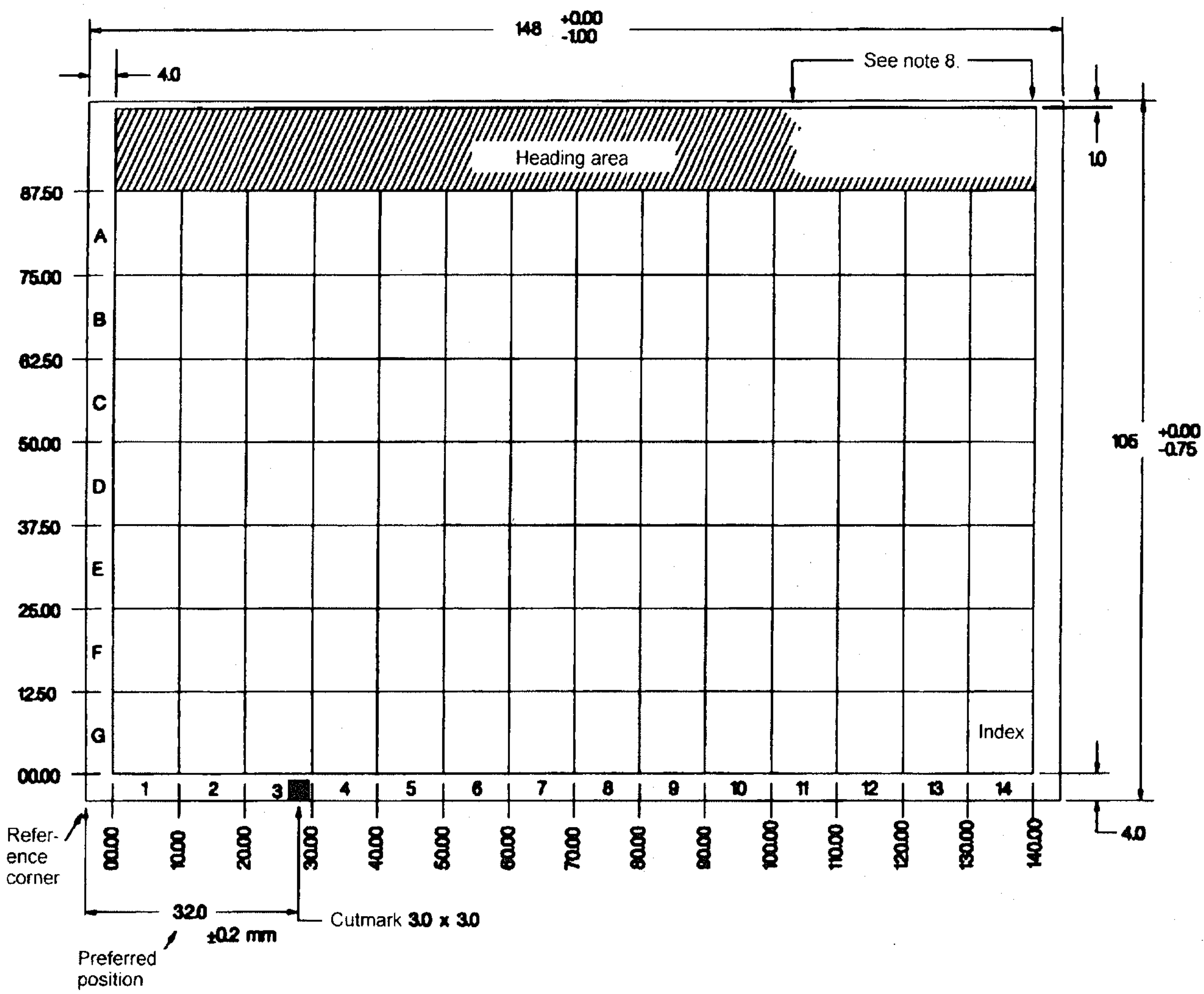
The document or identification number should be in the extreme left portion of the heading area.

4.17.2.2 Alphanumeric characters

All alphanumeric characters in the heading should be upright and right-reading. The entries should be eye-legible or readable without magnification.

4.17.2.3 Machine readable codes

The heading area may also contain machine readable characters and optical code. When used, machine readable codes, such as bar codes, should be placed in the top right-most portion of the heading area with vertical dimensions not exceeding 6.25 mm (0.25 in).



NOTES
1 Format: 14 columns × 7 rows = 98 frames.
2 Nominal reduction 1:24.
3 Dimensions in millimeters.
4 Grid lines shown do not appear on microfiche.
5 For location and dimensions of the notch or corner cut, see 4.5.
6 Dimensions whose tolerances are not specified are ± 0.5 mm.
7 Precut microfiche dimensions apply at time of rawstock cutting.
8 Area reserved for machine readable characters or optical codes.
9 Format dimensions apply at the time of exposure.

Figure 8 — Microfiche format 24/98

4.17.2.4 Sequencing multiple microfiche

When multiple trailer microfiche are used, all microfiche in the set should be sequentially identified. If possible, the final sequence number should show on each microfiche of the set. For example, if it can be determined prior to microfilming that there will be a total of 55 microfiche in a collection, each microfiche would be numbered as follows: “1 of 55”, “2 of 55”, and the like, up to “55 of 55”. The information should appear in the extreme right portion of the heading area, immediately below or left of machine readable characters or bar codes when these appear in the extreme right portion of the heading area. This numbering system is a valuable tool for filing and maintaining collection continuity. With adequate planning and preparation, the numbers of the first and last pages contained on each microfiche can be displayed in an eye-readable type size in the header area. This information is helpful when searching for a particular microfiche of a serial publication. See ANSI/NISO Z39.32.

4.17.2.5 Frame identification

Individual rows of frames in a microfiche may be assigned letters, and the columns may be assigned numbers. This permits specific frames to be located by a coordinate made up of a letter and a number. For example, frame C8 would be located in the third row down and the eighth position to the right. Some microfiche readers have pointers attached to the microfiche carrier pointing to a grid pattern or coordinate template. With the microfiche properly positioned between the glass plates of the carrier, the pointer will indicate, with reasonable accuracy, the page being displayed on the reader screen. In order for such a technique to be of value, an external index must be prepared that indicates information found at these coordinates.

4.18 Roll-film indexing

4.18.1 General

Film copies should be arranged, identified, and indexed so that an individual document or series of documents can be located easily. Pre-indexing systems require the completion of certain work prior to filming. For example, a sequence number may be stamped or inscribed on each page of each document after it has been correctly collated. Documents with artifactual value should not be numbered without the owner's permission because the process can cause irreparable damage. Some cameras can record sequence numbers automatically or expose a numeric display next to each image during filming. External indexes can be created from the film. Other indexing and retrieval techniques involve

— flash cards;
— horizontal bars parallel to film edge;
— odometers;
— image counts;
— optical codes.

Figure 9 depicts some roll-film indexing techniques.

4.18.2 Sequential numbers

Sequential numbers may be filmed in each frame. Figure 9 illustrates one type and location. The index can be prepared during or after filming, and it may give file breaks, file units, or individual document and corresponding frame numbers. Indexes can then be created in the same fashion as they are for printed works. OCR-B font is recommended for sequence numbers.

4.18.3 Flash cards

Flash cards that are of different size and appearance than the documents (for example, clear letters on a dark background) and that are filmed between documents help a viewer determine breaks in files and localize searches for particular documents. See Figure 9.

4.18.4 Odometers

Odometers indicate the approximate distance from the beginning of a roll of film to a particular document location. The index can be prepared after filming, giving the file breaks and the corresponding odometer readings. If the camera is equipped with an odometer, the indexing can then be done while documents are being filmed.

NOTE – Frequently there is no correlation between odometers from different manufacturers of cameras and readers. See Figure 9.

4.18.5 Document-mark indexing

Document-mark indexing uses the technique of filming marks (blips) above each document or frame, below it, or both. These marks are counted by a photoelectric device on the reader to locate the desired image. An index is usually constructed for the coded film after the filming is completed. See Figure 9 and ANSI/AIIM MS8.

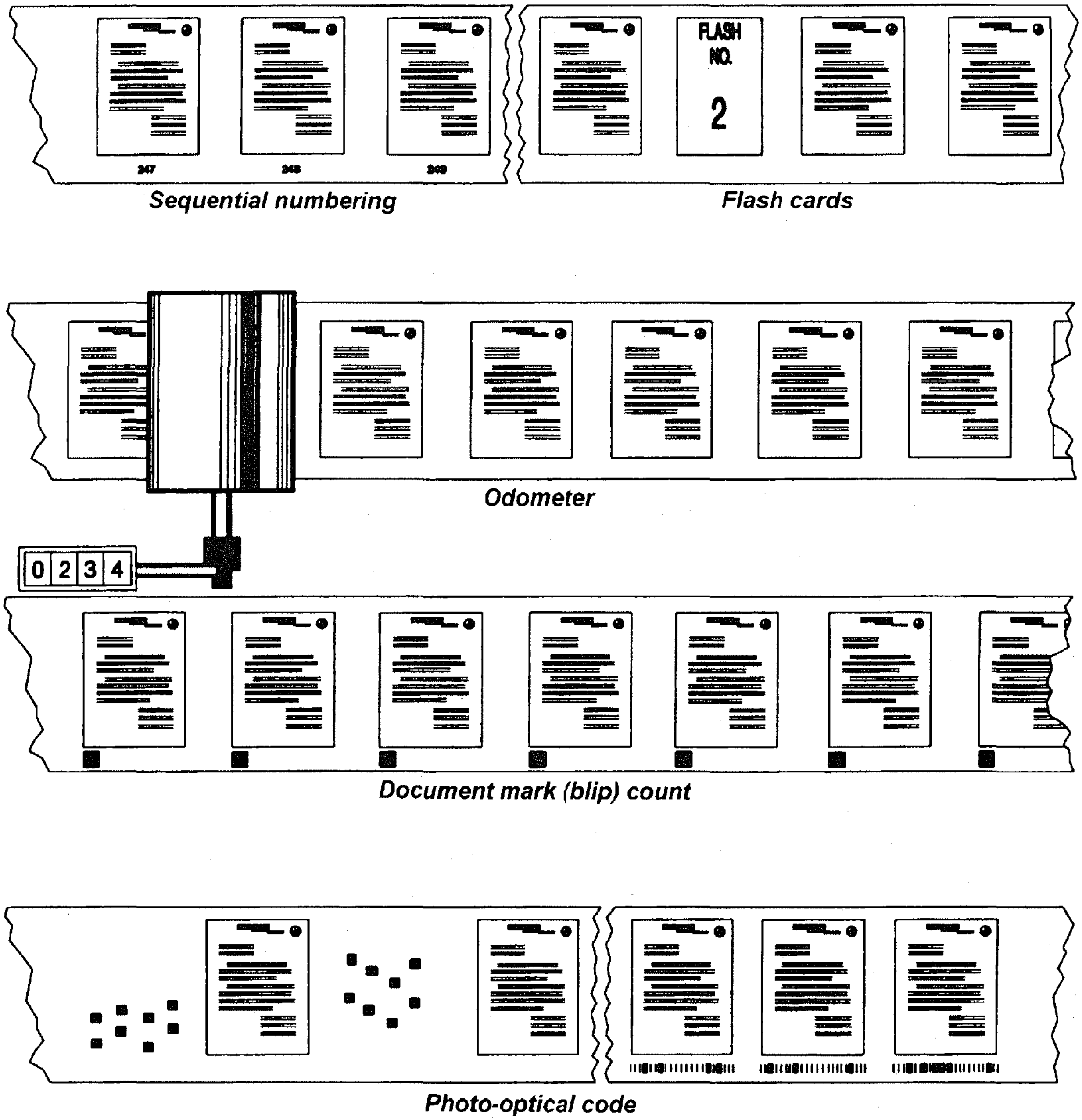


Figure 9 — Indexing methods used on roll film

4.18.6 Photo-optical code indexing

Unique photo-optical code indexing is based on optical codes recorded on film at the time of filming. Each frame or image is assigned a code number. Microfilm viewers equipped with sensors scan the codes at high speed and stop at the pre-selected frame or image. The index must also indicate which roll is to be searched. See Figure 9.

4.18.7 Side or bottom date strips

For voluminous serial publications such as newspapers and periodicals, it is helpful to place the dates of publication at the side or bottom of each frame. Various techniques can be devised for readily changing the information while the operator is microfilming the documents. One method involves putting the variable information on a scroll that is manually transported beneath cutouts or openings in the camera bed. Another method that works well is sticking white vinyl numbers and letters on short pieces of black flexible magnetic strips. Numbers and letters may then be sprayed with clear lacquer to maintain reflectance (whiteness). These are then held magnetically to strips of black sheet metal that have been positioned on the camera bed.

4.19 Leader and trailer

Leaders and trailers (the unexposed portions of film at the beginnings and ends of reels) serve a variety of purposes. After threading a camera, advancing the fogged portion of film out of the exposing path prevents superimposing images onto fogged areas. Before unloading the camera, advancing the film and creating adequate trailer serves to prevent fogging by providing several wraps around the exposed portion of the film. Because there might be threading leader requirement variations between cameras, it is suggested that the operator refer to specific instructions supplied with the specific camera.

Caution: More leader and trailer might be required if ambient (surrounding) light levels are high.

If a residual thiosulfate test area is required, a clear portion of the original leader will be cut off after processing, so additional leader should be made available. Leader and trailers of at least 500 mm (20 in) should be provided on use copies to allow for threading on a film reader and to reduce risk of damage to the imaged portion of the film, either through poor handling or environmental pollutants.

If the film is to serve as a master for duplication, 3 ft (0.9 m) or more of leader might be necessary to permit the image area to reach uniform full speed before entering the exposure section of the duplicator. If a stabilized speed is not reached, focus problems, overexposure problems, or both might be evident on the duplicate copy. If additional leader is necessary, it might be added to the masters after processing.

4.20 Reading equipment

Readers are categorized by type of viewing screen. Front screen readers have a reflective surface (usually white) onto which the image is projected. The screen is usually positioned at an angle that approximates the actual document position.

Rear screen or rear projection readers have a frosted, translucent glass or plastic screen onto which the image is projected. The image is projected onto the rear surface of the screen while the person who is viewing looks at the front surface. The screen angle is usually vertical or tipped slightly forward at the top to prevent reflections. Most screens are gray (neutral); however, blue screens are common. Because each provides a significantly different image appearance and contrast, the choice is an individual matter. Roll-film readers can have manual or motorized film transport systems. Microfiche readers normally have manual systems for positioning the images.

4.21 Packaging

Roll film and microfiche should be enclosed for transit, use, or storage. Roll film can be wound onto inert plastic reels and inserted into cardboard boxes or wound onto the core of self-threading type cartridges. All practical attempts should be made not to overload reels; that is, the film should be below the outer edge and preferably no closer than 4.5 mm (0.18 in) from the outer edge of the reel. Film should be wound with the start target at the outer end and in accordance with ANSI/AIIM MS 14. Rubber bands should not be used on microfilm reels. Paper bands are often used to confine roll film to reels. Microfiche (one or several) are routinely inserted into paper envelopes. All filing enclosure and storage materials must be photographically inert and meet chemical and mechanical criteria if the film contained is to maintain the desired LE. Such requirements are described in ANSI IT9.2.

4.22 Storage location

Proper storage of the camera master can prove vital to the film's LE and should be considered essential. Silver microfilm is sensitive to many common airborne pollutants and can be permanently damaged by excessively high temperature, relative humidity, or both as well as rapid fluctuations in temperature and relative humidity that are in the normally acceptable range. Environmental pollutants and chemicals from improper enclosure materials will eventually cause the silver image to oxidize at a rate proportional to the relative humidity of the storage area. Choose a storage location that is kept free of contaminants and that provides a stable (non-fluctuating) environment. See clause 15 for more information about film storage, clause 16 for more information about inspection, and ANSI IT9.11.

4.23 Sulfide treatment

A post-processing chemical bath, which partially or totally converts metallic silver grains to silver sulfide, provides protection against oxidants in poor storage or use environments. See 9.4.1.1 for more information about sulfur.

5 Document preparation

See ANSI/AIIM TR15 for more information about preparing documents.

5.1 Sequencing of documents

Record series or files are usually filmed in the order in which they were originally created and maintained. A pre-filming organization stage provides an ideal opportunity for organizing files into a sequence that produces the greatest value to the end user. Misplaced sheets, pages, folders, or other file units should be put in the correct order; and extraneous documents should be removed. Every effort should be made to obtain items missing from files so that the film can be as complete as possible. (If missing pages, documents, or other units cannot be located, "missing page" and "missing document" targets should be inserted. See 4.10 for more information about targeting.) If their size, physical form, or other constraints prevent items from being microfilmed (for example, exhibits in legal files), a target identifying each item and explaining its omission should be filmed at the item location in the file.

5.2 Microfiche page layout

Prior to creating a microfiche master, plan a page layout. Establishing beginning pages, ending pages, and targets will help determine the total number of microfiche in a collection. The actual numbering sequence best suited for each microfiche header should also be incorporated into the page layout (for example, "Fiche 5 of 24").

5.3 Determining data or file break

The preparer of original document files should determine the approximate number of images that will fit on a roll of film. Roll breaks should be designed to fall at logical breaks in a file (for example, at ends of subjects, dates, volumes, files, or storage containers). In addition to the length and width of a roll of film, the number of frames that a film will contain can be determined by

- — reduction ratio;
- — size of original document;
- — pulldown frame size on planetary cameras;
- — orientation of images;
- — film thickness;
- — filming requirements for unit records;
- — special leader and trailer requirements;
- — filming mode.

Several of these factors indirectly determine the amount of film advanced per frame. Some cameras have a preset amount of film; on others, it is variable. Equipment manufacturers often provide information indicating the number of frames a roll should contain.

For a planetary camera with adjustable film advance, table 3 may be used as a guide. The formula in table 3 may be used for planetary cameras with fixed film advance. Table 2 provides microfiche formats, document sizes, and reduction ratios.

Table 3 — Planetary roll-film camera (with adjustable film advance) — Approximate number of frames for 30.5 m (100 ft) roll of 16 mm or 35 mm film

Document dimension along length of film		Reduction ratio (simplex format)														
mm	in	1:8	1:10	1:12	1:14	1:16	1:18	1:20	1:22	1:24	1:26	1:28	1:30	1:32	1:34	1:36
102	4.0	2180	2670	2820												
152	6.0	1500	1850	2180	2510	2820										
203	8.0	1140	1410	1670	1930	2180	2430	2670	2820							
216	8.5	1070	1330	1570	1820	2070	2290	2530	2750	2980						
254	10.0	920	1140	1360	1570	1780	1980	2180	2380	2570	2760	2820				
305	12.0	770	960	1140	1320	1500	1670	1850	2020	2180	2350	2510	2670	2820		
356	14.0	670[1]	830	990	1140	1300	1450	1600	1750	1900	2040	2180	2320	2460	2600	2730
406	16.0		730[1]	870	1010	1140	1280	1410	1540	1670	1800	1930	2060	2180	2300	2430
457	18.0			770	900	1020	1140	1260	1380	1500	1620	1730	1850	1960	2060	2160
508	20.0			700[1]	810	920	1030	1140	1250	1360	1470	1570	1670	1780	1880	1980
559	22.0				740[1]	840	940	1040	1140	1240	1340	1440	1530	1630	1720	1820
610	24.0				680[1]	770	870	960	1050	1140	1230	1320	1410	1500	1590	1690
660	26.0					720[1]	800	890	970	1060	1140	1230	1310	1390	1470	1550
711	28.0					670[1]	750[1]	830	910	990	1070	1140	1220	1300	1370	1450
762	30.0						700[1]	770	850	920	1000	1070	1140	1220	1300	1370
813	32.0							730[1]	800	870	940	1010	1080	1140	1210	1280
864	34.0							690[1]	750[1]	820	880	950	1010	1080	1140	1210
914	36.0								710[1]	770	840	900	960	1020	1080	1140
965	38.0								680[1]	740[1]	790	850	910	970	1030	1080
1020	40.0									700[1]	760[1]	810	870	920	980	1030
1070	42.0									670[1]	720[1]	770	830	880	930	980
1120	44.0										690[1]	740[1]	790	840	890	940
1170	46.0											710[1]	760[1]	810	860	900
1220	48.0											680[1]	730[1]	770	820	870
1270	50.0												700[1]	750[1]	790	840
1320	52.0												670[1]	720[1]	760[1]	810

NOTES

1 Number of frames per roll = [Length of roll (less leader and trailer)]/[Film advance (pulldown)] = (1200)/(0.403 in) = 2980. Use either inches or millimeters, but *do not mix* the units of measurement.

1) The numbers shown below the rule apply only to 35 mm film.

5.4 Target insertion

The preparer should place appropriate targets in proper locations of the file before it is given to the microphotographer for filming. See 4.10 for more information about targeting.

5.5 Bound documents versus loose documents

Given a choice, it is more desirable to photograph loose, single sheets than to photograph bound material. In addition to being filmed at higher speeds, loose documents lie flatter, remain motionless, and are easier to turn and keep positioned. See 8.3.2 for more information about microfilming bound documents.

5.6 Removal of bindings

Experience has shown that tight bindings cause information loss due to the document being out of focus and due to shadows and reflections. It therefore might be necessary to unbind documents, providing the record custodian has authorized such measures. Procedures range from simply cutting the stitches to shearing off the bindings with a guillotine trimmer. Prior to guillotining, books should be checked for foldouts and illustrations that continue through the gutter. A great deal of care must be exercised when handling fragile materials. Bindings with artifactual value can be photographed with various degrees of success depending on visual contrast of the bindings and camera exposure level used.

When unbinding is neither possible nor practical, a book cradle, which permits filming a partially or completely opened book, might be necessary. With proper authorization, blackened wooden dowel rods of various diameters may be inserted between a book's cover and spine to elevate the gutters. Though sometimes harmful to brittle bindings, raising gutters to create a more-even object plane will minimize focus loss, reflections, and shadows.

5.7 Removal of fasteners

After documents have been arranged in the order in which they are to be microfilmed, all staples, paper clips, and other items should be removed. If a rotary camera will be used, this procedure is mandatory. Such items can jam, scratch, or damage the camera transport mechanism or the glass flats. In planetary camera operations, it might be necessary to remove staples, paper clips, and the like so that information appearing on both sides of a document can be recorded. If an entire file is to be filmed, both sides of all documents should be examined for endorsements, file marks, time stamps, or other information. Removing all staples or other fasteners before filming generally results in faster filming. Non-camera staff may replace the fasteners after filming (if necessary to maintain the original file integrity).

5.8 Quality of documents

Before starting a microfilming project, one should assess the quality of the documents being photographed. Mechanical considerations, including size, thickness (if bound), tightness of binding (if bound), brittleness, folds, and creases, will dictate methods used to physically handle the documents. Photographic considerations include

- — whiteness or reflectivity of the paper;
- — opacity of the paper;
- — density of the ink, size, and font of the characters;
- — ink bleed-through from verso;
- — presence of stains or oxidized (browned) paper;
- — presence of graphs, charts, overlapping objects, illustrations, or colored inks.

Each combination of variables will require slightly different handling, exposing techniques, or both.

5.9 Repair of documents

All imperfections (such as mutilations, tears, stains, and obliterations) that affect the legibility of the document should be repaired if possible, with authorization granted by the source document custodian or publisher. If documents have been repaired with pressure-sensitive tape, camera operators should frequently inspect the glass plates in the exposing plane of rotary cameras or book cradles; adhesive from the tape can transfer to the plates, obstructing the optical path or jamming a rotary camera. Imperfections that do not either affect any text or illustrations or jeopardize the camera transport mechanism may be ignored.

5.10 Enhancing text quality

For moderately faint text, the most effective method of enhancing poor-contrast documents is exposing the documents at appropriate density levels.

Weak (handwritten or printed) information contained in legal or historical documents should not be enhanced except by photographic methods. For example, a yellow filter (Wratten 9 or 12 or its equivalent) over the lens will brighten oxidized (brown) paper, increasing the apparent contrast of the text versus the background. Because using a filter will require increased exposure levels, step tests should be conducted to determine correct exposures. Correct exposure produces adequate background density while maintaining low density in the thinnest lines, letters, numbers, and the like.

5.11 Final document inspection

The documents prepared for filming should be given a final inspection to determine that the proper arrangement has been maintained while the documents were being prepared or repaired, that all targets have been correctly placed, and that the documents are ready to be microfilmed. This final check is an essential quality-control step that should reduce the risk of creating film records with missing documents, out-of-order documents, or both. All documents received at the filming station should be "camera ready". Camera operators should only add applicable camera station identification and quality assurance (technical) targets.

6 Equipment and supplies

Equipment and supplies are needed for production, for inspection, and for post-production (storage).

6.1 Production equipment and supplies

6.1.1 Camera

A microfilm camera is a precision instrument used to photograph documents. It should provide a method for adjusting the exposure level and be capable of producing microfilm that meets requirements defined by the user. Some cameras permit exposure adjustment by allowing changes in brightness or intensity of illuminating lamps. Others permit adjustment by allowing changes in exposure time or shutter speed. Some offer both. The aperture size or "f/number" of the lens is usually fixed at a diameter that provides optimum resolution. The aperture size is not adjustable.

Four types of camera discussed in this standard are

— planetary camera;
— flow or rotary camera;
— step-and-repeat camera;
— camera-processor.

6.1.1.1 Planetary camera

With a planetary camera, both the document and the film are stationary while the exposure is being made. Planetary cameras are required for materials including

— permanently bound records;
— books;
— large-size documents;
— documents with stapled or overlapping/layered attachments;
— documents that are unlikely to survive rotary processes without damage;
— materials being microfilmed for preservation purposes.

Planetary cameras can provide higher resolution than rotary cameras and can be required for filming documents that have very fine detail. Such detail requires higher image quality than most other camera types (such as rotary) are capable of delivering. Although some planetary cameras are restricted to either 16 mm or 35 mm formats, many planetary cameras are designed to use both. See figure 10.

6.1.1.2 Flow or rotary camera

Rotary cameras provide rapid document capture for high-volume operations. In a rotary camera, both the document and the film are in motion at the time of exposure, at a ratio that exactly matches the reduction ratio. For example, if the reduction ratio is set at 1:24, the documents move through the camera 24 times faster than the film. If a change is made to the reduction ratio, the document throughput speed remains constant while the film transport speed is automatically adjusted accordingly. Discrepancies between film and document motion can contribute to a falloff in resolution. Random malfunctions in the document feed/transport mechanism or misalignment of the document feed guides can cause image alignment problems. Most flow cameras are designed to use 16 mm film; however 35 mm flow cameras are available. Neither, however, is generally used for precision microfilming. Due to recent advances in mechanical and optical performance, some rotary cameras are capable of producing good-quality images with higher resolution than some of the very old planetary cameras are capable of producing. Throughput should not be given a higher priority than image quality.

6.1.1.3 Step-and-repeat camera

A step-and-repeat camera is a planetary device used to film documents in any of several common microfiche formats. When using 105 mm film, an internal mechanism moves the film back and forth in a grid pattern to produce the desired rows and columns making up the body of the microfiche. Most step-and-repeat cameras have provisions for photographing information into header areas of the microfiche.

6.1.1.4 Camera-processor

Some cameras that are designed to generate microfiche or aperture cards also contain the equipment necessary to quickly process the exposed film to satisfy most data retention period requirements. (See ANSI/NAPM IT9.1.) The film supply is usually a long length of 105 mm camera film. When the last frame on the microfiche is exposed, the film is cut to a length of 148 mm. It passes through a development chamber and emerges as a fully processed microfiche master.

6.1.2 Exposure meter

Metering systems of various sophistication are commonly used to help determine correct exposure. With manual systems, the camera operator aims a photocell towards a representative area of the illuminated document. The meter reading, which indicates the amount of light being reflected from the paper, guides the operator in making an exposure adjustment. With adequate training and experience, these systems are very effective.

More-sophisticated metering systems continuously measure document reflectance and automatically adjust the camera lamp brightness.

Fully automatic systems, which cannot be manually overridden by the operator, tend to create microfilm images that have constant density if they are properly calibrated and maintained. However, if document contrast varies widely, constant density in the film might not be a desirable goal. Automatic exposure systems are beneficial only if the photocell is aimed at a representative portion of the document. The oversimplified and often incorrect principal under which these systems operate is that darker documents always require greater exposure. If, for instance, a photocell is aimed at a dark illustration, the system is “fooled into thinking” that it is simply a document on dark paper, and an exposure increase incorrectly results. An excessive increase can result in overexposing any normal text contained on the same document.

Another problem associated with automatic exposure controllers involves sensitivity of the photocell. Sensitivity of the photocell must closely match the color sensitivity of the film being used. If the photocell does not respond to colors (spectral response) in an identical manner to that of the film, the photocell can indicate an exposure change that is inappropriate. Modifying the sensor's spectral response by adding colored filters can provide better correlation, but a perfect match is highly unlikely.

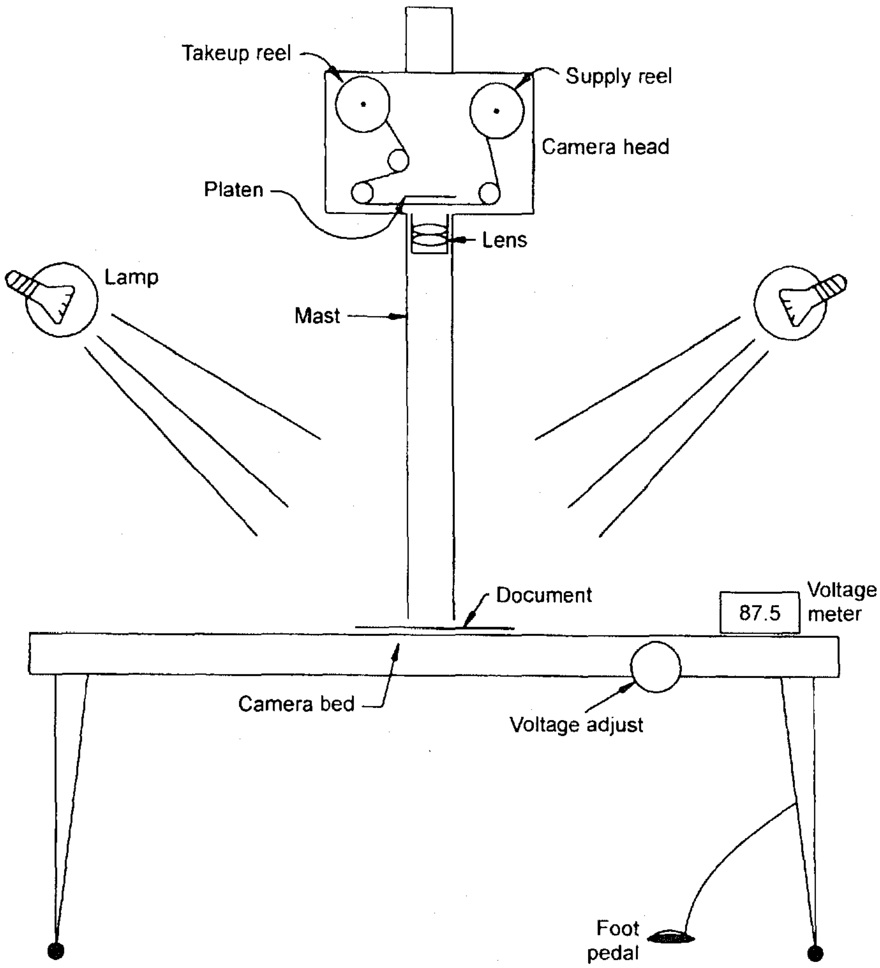


Figure 10 — Generic planetary camera

6.1.3 Reflection densitometer

The reflection densitometer is designed to measure the amount of light being reflected from a surface. It is possible to measure the reflectance value of a document and use these numbers to help the camera operator make more-accurate exposure adjustments. Subtle differences in paper whiteness can be apparent to the reflection densitometer even if they are not apparent to the human eye. With more-obvious differences in whiteness, particularly within a document, the reflection densitometer allows subtle changes in exposure adjustment to capture the best image density. See 6.2.2 for information about transmission type densitometers.

6.1.4 Camera lighting

Camera lights illuminate a document being photographed. High-contrast camera film stock is quite sensitive to even minor variations in the balance of camera lights. For microfilm images to have uniform density, corners and edges of the frame must be equally illuminated yet slightly brighter than the center. Not only do documents need to be correctly illuminated, but the overall amount of light must remain constant from frame to frame. Camera lighting balance should be checked regularly. See 7.1.4 for more information about density uniformity.

6.1.4.1 Voltage control device

Electrical supply (voltage) sometimes fluctuates. The supply is referred to as "incoming" or "line voltage". The amount by which it fluctuates depends mainly on the demand placed on the central supply by other local users. Such variations will have significant impact on the density of microfilm images. Variations as small as 1 V can contribute a density shift of 0.07. Therefore, dedicated power lines should be used. Fluctuations will be minimized through the use of a solid-state voltage control device that dampens incoming voltages to within a few tenths of a volt. Such devices are highly recommended.

6.1.4.2 Voltage readout device

Another major element in providing consistent exposure of the documents is the voltage readout device. Analog or "dial type" voltage meters are not precise enough for setting or adjusting camera exposure. Many dial meters have minimum graduations of as much as 2 V to 5 V. These graduations are too coarse for precision microfilming.

Added precision is possible through the use of a digital voltage readout that indicates changes to tenths of a volt.

6.1.4.3 Overhead lamps

Source documents must be illuminated with overhead lamps. Several categories of lamps exist, and each has distinct advantages and disadvantages listed below. Types of lamps include incandescent, quartz halogen, and fluorescent.

6.1.4.3.1 Incandescent

In the past, the illumination source on most planetary cameras was a set of four incandescent photoflood lamps and, when operated at less than 80 % of the maximum operating voltage, tended to last for long periods of time. As incandescent lamps "burn", tungsten gets hot enough to evaporate from the filament, adhering to the inner walls of the glass bulb. This slowly reduces brightness of the bulb and decreases the amount of light cast on documents being filmed. Invariably, the four lamps darken at different rates, disturbing the illumination uniformity. Likewise, if lamps are bumped or otherwise disturbed, uniformity will be negatively affected.

If one lamp burns out, all four should be replaced. Two reasons follow: the new lamp will produce more light than any of the remaining aged lamps, making balance difficult; one lamp burning out usually indicates the remaining lamps will soon burn out. Some technicians advocate "burning in" or seasoning new lamps by operating them at full brilliance for several hours prior to putting the camera into service. If serious density instability is encountered, seasoning is recommended.

6.1.4.3.2 Quartz halogen

Quartz halogen lamps offer some distinct advantages over conventional incandescent lamps. The amount of light generated remains fairly constant over a much longer period of time than with incandescent lamps, and the output remains constant until they fail totally. The bulb or envelope on quartz halogen lamps is "self cleaning" in that the evaporated tungsten deposits back onto the filament rather than on the bulb. For this process to take place, the lamp must be operated at a minimum temperature generally thought to be attained at 70 % of maximum operating voltage. If quartz lamps are operated at lower voltages and do not reach these minimum temperatures, their life will be shortened, and their light output will be inconsistent. Quartz lamps produce optimal light output when operated at consistently high temperatures. For precise density control, lamps should be allowed to burn for 10 s to 15 s before making exposures. If turned off for only a few seconds and then turned back on, the light output does not instantly refresh to the level prior to being turned off.

Some quartz lamp fixtures are equipped with hinged metal flaps, referred to as "barn doors". These adjustable doors make it possible to precisely shade or trim the amount of light falling on the camera bed, simplifying the task of light balancing. Some fixtures have channels into which diffusion screens can be inserted. These screens produce a more-uniform "blanket" of illumination.

6.1.4.3.3 Fluorescent

Banks of dimmable fluorescent lamps are sometimes used with cameras designed for oversized documents (such as engineering drawings). In addition to generating significantly less heat, they provide, with the assistance of moveable shields, uniform lighting over large areas. Because aging fluorescent lamps are prone to flickering, variations in light output can be a significant source of exposure error. Interruptions to light output indicate the need for replacement, and as with other types of lamps, fluorescent tubes should be replaced as a set.

6.1.4.4 Sub-illumination lamps

For documents that must be viewed by transmitted light (such as positive transparencies or negatives), the camera lighting source must be located beneath the documents.

The usual source is a bank of low-wattage incandescent or fluorescent lamps covered by a sheet of diffusion material with uniform translucence (such as opal glass or milk glass). Arrays of separate lamps that are individually dimmable make correct illumination balance more controllable.

6.1.5 Processor

A processor for silver gelatin film is a mechanical device that provides a series of chemical and physical treatments to exposed film, producing a final photographic image. The standard process includes developing, washing, fixing, washing, and drying.

With all processors, there are several variables that must be tightly controlled if consistent results are to be achieved. The most critical variables are
- developer temperature;
- developer concentration or strength (developer replenishment rate);
- development time (transport speed);
- developer agitation (recirculation);
- washing.

Processing machines range from small tabletop units that process film at speeds ranging from 5 ft to 10 ft (from 1.5 m to 3 m) of film per min up to large, permanently installed deep tank processors that will process film up to 300 ft (91.5 m) per min.

Deep tank processors generally provide a greater degree of developing consistency than tabletop processors. Primary reasons include better chemical and thermal stability due to a larger volume of developer liquid; and longer development times due to a larger developer section. Some tabletop processors might not have adjustable temperature and speed controls, and the lack would limit versatility with respect to adjusting and compensating for incorrect exposure.

Types of processors include tabletop, horizontal-path, and helical/serpentine deep tank. See figure 11.

6.1.5.1 Tabletop processor

Tabletop units are characteristically small in size and can be relatively low in cost. In some instances, quality is comparable to that available from the most sophisticated large processors. Even though most controls are straightforward, operator training is required to achieve consistent results. Most tabletop processors use a small quantity of developer and have short development times, making chemical concentration and temperature critical. Because developer concentration is a major variable, a continuous developer replenishment system is recommended. Such systems inject fresh developer concentrate only while film is being processed. Some systems must be turned on and off manually. A batch type replenishment system, in which a quantity of fresh solution is manually added after processing a given quantity of film, will provide a marginal measure of developing activity control. Some units require water and drain hookups, consuming 1/2 gal(US) to 2 gal(US) of water per min to achieve adequate washing. Other types have self-contained wash water systems that need replenishment or total replacement after processing a fixed quantity of film. Most tabletops have self-threading capability and can be operated under normal room light conditions after film is loaded. Some units have accommodations for 16 mm, 35 mm, and 105 mm film widths. Accessories might include
- stand;
- sink;

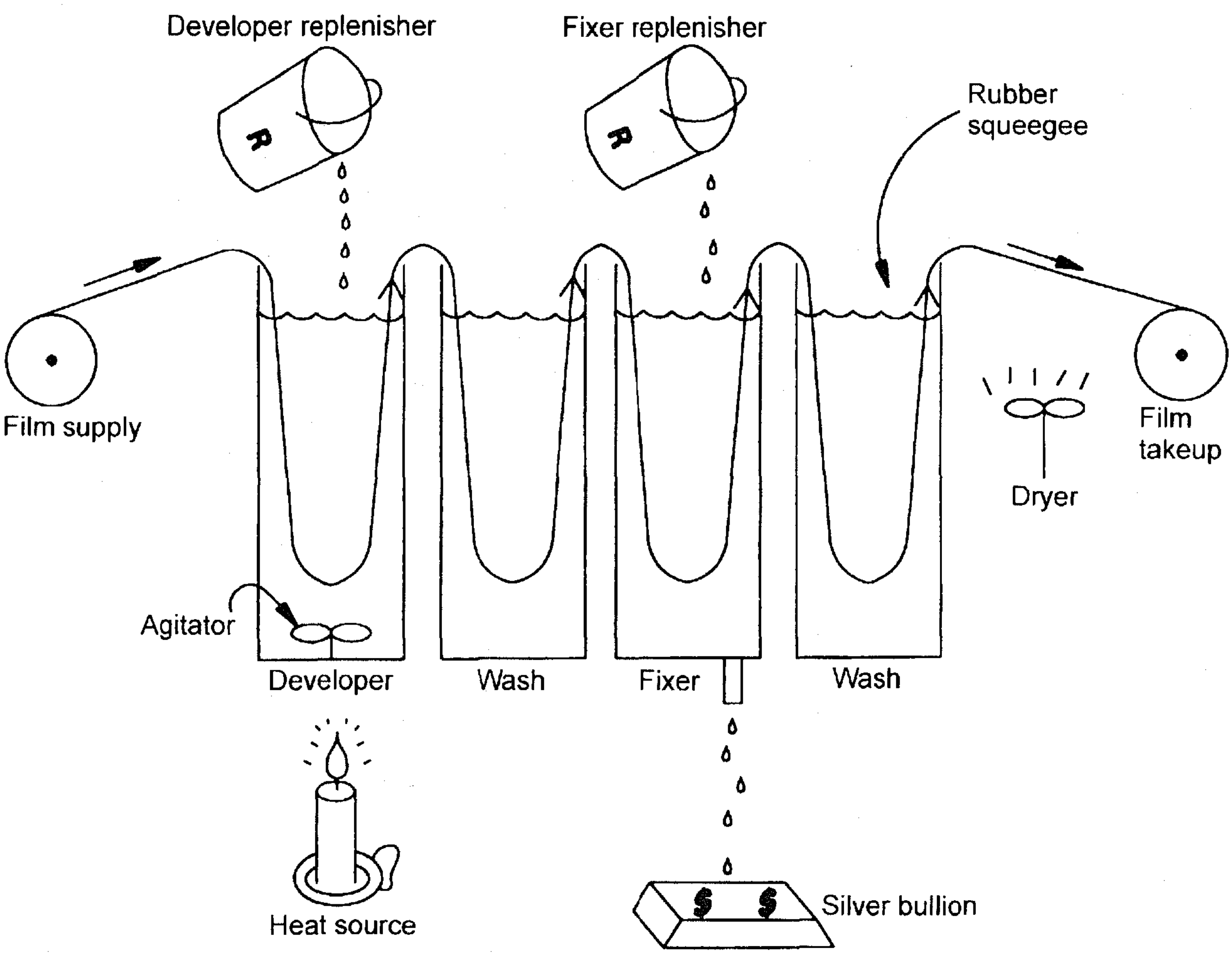


Figure 11 — Generic processor

— thermostatic water-mixing valve;
— film-loading cassettes;
— magazine and cartridge adapters;
— chemical replenishment systems;
— dual-strand mechanisms.

6.1.5.2 Horizontal-path processor

Horizontal-path units, which are typically tabletop or freestanding consoles, transport film horizontally through the processing solutions. Transport speeds range from 2.5 ft/min to 10 ft/min (from 0.76 m/min to 3 m/min). Modern films and chemicals combined with high temperatures permit the short solution treatment time needed by these processors. They are suitable for wide films (105 mm) or multiple strips of narrow films (16 mm and 35 mm). Most have self-threading capability and can be operated under normal room light conditions after film is loaded. Available accessories include

— stand;
— sink;
— thermostatic water-mixing valve;
— film-loading cassettes;
— magazine and cartridge adapters;
— chemical replenishment systems;
— dual-strand mechanisms.

6.1.5.3 Helical/serpentine deep tank processor

Helical/serpentine deep tank processors, sometimes custom made, evolved from motion picture processors and are capable of operating at speeds up to 300 ft/min (91.5 m/min). Processors can be designed to provide conventional or full-reversal processing. These require pre-threading with plastic leader to pull film through the processor tanks of chemical solutions. Medium-size deep tank processors, which use light-tight film cassettes, require a darkroom for cassette loading. Large deep tank processors can require totally dark conditions where film is loaded and developed. The final washing and drying steps can be performed under normal room light conditions if appropriate light-tight walls or partitions are constructed. Accessory features might include

— stop bath provisions;
— chemical replenishment;
— solution recirculators;
— dye removal;
— agitators;
— filters;
— squeegees;
— polysulfide toning;
— cascading wash water recovery system;
— silver recovery;
— wash water desilvering;
— extra washes;
— Photo-flo™ or equivalent final rinses.

6.1.6 Sensitometer

A sensitometer is a photomechanical device designed to produce precision exposures on photographic films and papers. Intensity of the lamp and duration of exposure are very tightly controlled, providing consistent exposure levels. A sensitometer can be used to create control strips for use in monitoring processing machine consistency and can evaluate and compare the photographic (sensitometric) characteristics of different films.

When creating and measuring processor control strips, the goal is to control as many variables as possible. The film's sensitivity level is maintained for long periods of time by keeping it refrigerated. The only major variable left in the monitoring system is the processor. Variations in density of the control strip can normally be attributed to the development action of the processor. These readings are plotted on a control chart with the center-line (average) and upper and lower control limits being statistically derived from previous processing experience. See 9.5 for information about process control.

6.1.7 Splicers

Types of splicers include

— tape splicers;
— solvent splicers;
— thermal splicers;
— ultrasonic splicers.

6.1.7.1 Tape

The most expedient means of joining two pieces of film is polyester tape. If dissimilar film types (acetate and polyester) must be joined, the only mechanically reliable splice is the tape splice. However, the adhesive used on most self-stick tapes is chemically reactive with the silver contained on microfilm and is therefore unsuitable for silver halide film. Tape should not be used for splicing LE 100 or LE 500 films. If tape cannot be avoided, for example when joining polyester films to acetate films, a tape with a polyester base and an acrylic adhesive should be used. Rubber-based adhesives should be avoided.

As tape ages and the splice stresses, the tape might become unstable and might allow the film to separate at the splice. When this occurs, a narrow band of adhesive might be exposed. This exposed adhesive will attract dust and dirt; it can transfer to adjacent wraps of film or cause problems with film transport mechanisms. See 6.3.2 for more information about splicing tape.

6.1.7.2 Solvent

Solvent splices are effective only on cellulose acetate microfilms. When using a solvent splicer, the emulsion layer must be mechanically scraped from one of the two pieces of film to expose the base material to the solvent. Shavings, which result from the scraping process, clutter the work area and can adhere to the film through static cling. An acetone-based solvent is applied to the freshly scraped section using a small brush. Care should be exercised to clean the splice area before applying the solvent. The base side of the other piece of film to be spliced is clamped in tight contact until the solvent chemically softens and subsequently fuses the two sections of acetate material.

Residual chemicals from solvents are known to be harmful to silver images. In addition, the scraping process results in a thinning of base material, weakening the splice. For both these reasons, solvent splices are generally not recommended. However, they are preferred to the thermal weld type splice for acetate-based microfilms.

6.1.7.3 Thermal

The thermal splicer, sometimes referred to as the "butt splicer", heats two sections of film base until they have fused or melted together. Upon cooling, the two halves bond. Because heat levels and dwell times are easily adjusted, acetate films are occasionally overheated. Overheating "drives off" the film base plasticizers, yielding a brittle splice. Being brittle, this splice can easily break when the film is wrapped around a small-diameter roller (such as the kind encountered in some duplicators). Excessive heating can also cause a splice to warp, possibly creating focus problems for contact duplication equipment.

6.1.7.4 Ultrasonic

Polyester terephthalate (polyester) film base is a thermal plastic, and as such, it can be melted and then fused while cooling. The only acceptable method of making a splice on polyester film base is ultrasonic welding. Properly made ultrasonic splices are extremely durable, flexible, and long-term splices. With ultrasonic welding, high-frequency sound waves cause molecules of film base to vibrate so rapidly that, through friction, they generate enough heat to melt the two pieces of film base together.

Ultrasonic splicers have two components that come in contact with the film: the "horn" and the "anvil". The horn vibrates, transmitting vibrations to the films being welded. The anvil is a fixed part against which the film is compressed. Due to the slight compression of the soft polyester material, a "nib" can form at both ends of the splice. These nibs should be trimmed flush with the edge of the film to prevent loss of contact during duplication. Such contact loss causes out-of-focus conditions.

6.1.7.4.1 Smooth

The anvil is a metal roller that slowly travels across the film area being spliced. If the anvil's surface is smooth and polished, the appearance of the splice will be smooth and uniform.

6.1.7.4.2 Zipper

If the anvil's surface is knurled or grooved, the resulting splice will be stronger than a smooth surface weld and take on the appearance of a zipper. This type of splice will reproduce with a great deal of contrast on subsequent generations and might be construed as a blip mark by counters and sensors.

6.1.8 Film length measurer

For duplication purposes, it is often necessary to know how many feet of film is on a roll. Standard footage measuring devices wrap the film around a rubber roller of known diameter with each revolution equivalent to a fraction of a foot. A counting device records the revolutions and converts them to a footage reading.

Some digital weighing scales have features that permit them to count units by weight. After programming and calibration of the scales to "know" how much a foot of a particular type of film weighs, they can then determine footage based on the weight. For accuracy, such items as plastic spools, reels, cores, fasteners, and wrappers that might be with the film must be consistent, and their weight must be deducted from the gross weight.

A simple but not consistently accurate method of determining film length uses a mathematical formula. Such known dimensions as roll diameter, core diameter, and film thickness are used as variables.

$$L = 3.1416 \times (D^2 - d^2)/(48 \times T)$$

where:

L is the length of roll in feet;

D is the diameter of the roll in inches;

d is the diameter of the film core in inches;

T is the thickness of the film in inches.

Example: The overall diameter of a roll of film is 8.75 in (222 mm) and the film is wound on a 3 in (76.2 mm) plastic core. Film thickness is 4.2 mils or 0.0042 in (0.11 mm). How many feet are on the roll?

In this case:

$D = 8.75$ in

$D^2 = 8.75 \times 8.75 = 76.5625$

$d = 3$ in

$d^2 = 3 \times 3 = 9$

$T = 0.0042$ in

$3.1416 \times (76.5625 - 9) / 48 \times 0.0042$
$= 1052$ ft

$3.1416 \times 67.5625 / 0.2016 = 1052$ ft

$212.2543 / 0.2016 = 1052$ ft
(or 320.65 m)

This calculation indicates the roll contains 1052 ft (320.65 m) of film.

6.1.9 Eye loupe with measuring reticle

Eye loupes containing a measuring reticle or scale are available. Such loupes are placed directly on top of an item being measured (film or paper). Metric units are read directly from the scale while looking through the loupe. Such reticles are used to measure the height of printed characters when using the Quality Index method for determining system resolution requirements. See 7.2.2 for more information about the Quality Index method.

6.1.10 Safelights

6.1.10.1 General

Safelights are lighting fixtures that, when equipped with properly colored filters and lamps of the proper wattage, permit handling of some raw or exposed films for short periods of time without fogging the films. Safelight filters are chosen to deliver a color of light to which the film is least sensitive.

Caution: Safelights, however, must be used with caution. The term "safe" is only relative and is based on certain distance, brightness, exposure time, and color requirements. Abusing any or all of the requirements can result in noticeable density changes on the film. Excessive exposure to safelight is initially evident in the high-density areas of the images. Only after high-density areas have been radically affected do clear areas begin to change.

Source document camera films are panchromatic and are by design sensitive to all colors of the spectrum: red, green, and blue.

Caution: As a result, it is recommended that reels of camera films be unwound only in total darkness. If used with extreme caution, dark green light from a Wratten 3 or equivalent safelight can be used for short periods of time. Such safelight exposure should be limited to leaders and trailers of exposed camera films.

If wound on opaque, solid-flanged spools, camera films can be loaded and unloaded in subdued or typical office environments for short lengths of times with no fogging.

6.1.10.2 Safelight testing

Safelight conditions should be tested whenever a change is made in film type, filter type, lamp wattage, or fixture location. Ideally tests should be conducted using short lengths (for example, 2 ft to 3 ft or 0.6 m to 0.9 m) of film containing a variety of exposure levels that will result in a range of density levels from *D*min to *D*max after processing.

If a sensitometer is available, expose two separate strips of film to the step tablet contained in the sensitometer. Film stock should be the same as that normally used in the area being tested. Immediately after exposure, put the strips into separate, light-tight containers. Take one strip to the test site. Determine where the film will be subjected to the most safelight during normal handling. Remove the exposed strip from the container and position it so that the emulsion side (dull side) is facing the safelight source. Expose it to the safelight for the maximum amount of time that production film would be exposed in normal practice. After exposing the strip for the appropriate length of time, place it back in the container. If possible, process both strips under total darkness conditions. If total darkness is not possible, use minimal safelight at the processor.

On the processed films, choose the step (of the 21 steps of exposure) that produced a density close to the highest working level encountered on production film. Read the same patches on both strips of film. If the readings taken from the high-density patches are different, then this is the amount of density change you can expect from this amount of safelight exposure. If this amount of density change cannot be tolerated, try the following:

a) move the safelight farther away;
b) replace the bulb with one of lower wattage;
c) aim the fixture in another direction;
d) cut down on the length of time the film is exposed;

e) shade the area where the film is most vulnerable;
f) choose a more-appropriate filter.

If there is no density difference between the two strips, the amount of safelight fog is too low to be detected and the safelight color, position, and wattage is acceptable.

Again, when processing the test strips, use minimal safelight. Not doing so might alter the test results. The goal in any well-managed microfilm laboratory should be to have zero safelight fog. Fog adds an additional significant variable that negatively affects good process control.

6.1.11 Film-cleaning machine

Devices designed for cleaning film range from small portable tabletop units with tacky rollers or webs of soft plush cloth to large, permanently installed machines that use heated solvents, vapor recovery, scrubbers, and ultrasonic agitation. Effectiveness varies considerably depending on the method and foreign material to be removed. The most effective cleaning results from a combination of mechanical scrubbing in conjunction with a solvent. This not only removes loose dust and dirt but also is effective on oily substances, tape residue, and other foreign matter.

Tacky rollers and devices that use webs of soft cloth work well for removing loose particles but are not as effective at removing tightly adhered materials or oily substances.

6.1.12 Film-cleaning solution

Chlorinated hydrocarbon type solvents have been used for cleaning film for many years. Although a very effective degreaser and film cleaner, carbon tetrachloride has been proven to be carcinogenic and is no longer available. Methyl chloroform (1,1,1 Trichloroethane), a very effective cleaning solvent, was used extensively in the past. However, in 1995 the Environmental Protection Agency significantly curtailed its use because of negative environmental impact.

Caution: A great deal of caution should be used when cleaning modern polyester-based microfilms with any type of organic solvent. Some films contain specialty coatings for static fog and Newton ring prevention, and depending upon the type, these coatings can soften and partially dissolve in the cleaning solvents, leaving permanent streaks and smears.

Caution: Although it must be used with extreme care due to its flammability, reagent grade denatured alcohol or isopropyl alcohol has been used with positive results on silver polyester-based film without causing damage to specialty coatings and the like.

Caution: Neither organic solvents nor alcohol should be used on diazo or vesicular films. Various components, including the title striping ink on microfiche headers, can dissolve.

Because neither of these film types contains absorbent material (such as gelatin), fingerprint oils tend to remain on the surface. They can be removed using a soft cloth with mild detergent and deionized water.

6.1.13 Film-cleaning wiper

One of the most important features of a wiper used for cleaning microfilm is that it not be abrasive. Although heavy cotton (flannel or terry cloth) is usually the material of choice, some synthetics clean as well. If the cloths are to be used over and over, they should be frequently laundered to remove oily buildups and harmful grit that could scratch film. Any detergent used in laundering should not contain additives (such as perfumes, fabric softeners, anti-static substances, optical whiteners, or brighteners). Such residue can transfer to the film and have a chemically harmful effect.

A better alternative is using a disposable wiper and discarding it when it becomes soiled. Such materials are sold for use in clean room operations as well as in the graphic arts industry for cleaning printing presses. Scanner wipes designed for cleaning the scanner drums can also be used for film. Most are available through scientific supply catalogs such as VWR Scientific, Fisher Scientific, Lab Safety, and the like.

6.1.14 Waterproof splicing tape

Although stainless steel staples can be used for joining lengths of exposed film to be processed or of clear leader to be used for threading purposes, they can damage rubber rollers and squeegee wiper blades. In general, staples should not be used in tabletop processors that use a large number of small diameter rollers or narrow passageways. In most instances, waterproof polyester splicing tape (such as 3M Brand Type 8421 or the equivalent) is a better alternative.

6.1.15 Opaque photographic tape

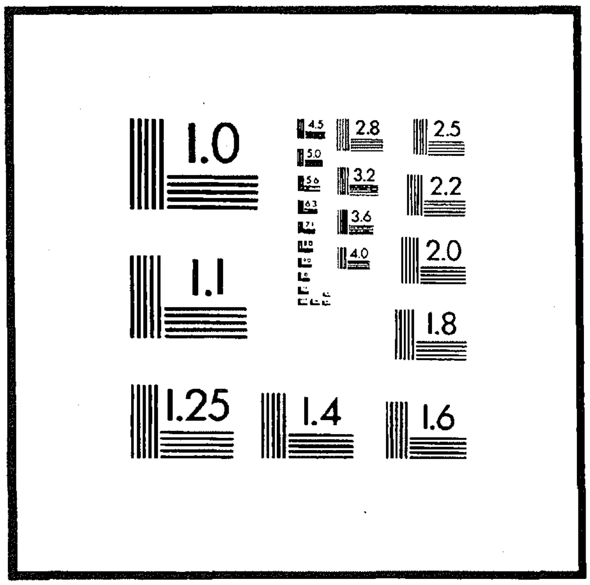
A supply item that has a multitude of uses in any photographic operation is black opaque tape (such as 3M Type 235 or the equivalent). It can be used for

- creating borders and masks;
- covering undesirable reflective objects and areas on the camera bed;
- taping down test objects and targets;
- sealing light leaks in cameras, canisters, and sensitometers;
- creating raised stops on the camera bed against which single sheet documents can be registered.

6.1.16 Resolution test chart

Resolution test charts are standard reference tools used to quantitatively determine the quality of a lens and the degree to which an optical system is in focus. The chart most commonly used in the micrographics industry is the ISO Resolution Test Chart No. 2, which contains a series of five horizontal and five vertical line patterns getting progressively finer. See figure 12. The patterns, which should be printed on dimensionally stable stock, range in frequency from 1 line and space per mm to 18 lines and spaces per mm. By microfilming five charts in one frame (one in the center and one in each corner of the camera bed) and then evaluating the images with a microscope, one can determine the ability of the system to record fine detail. Resolution test charts are available through a variety of sources, including AIIM International. The charts can be purchased singly or as large prefabricated targets that contain an array of five or more charts. These prefabricated targets are frequently not as large as the documents being microfilmed; the outer charts might not coincide with the outer extremities of the documents. When necessary, these targets, in sheet form, might be cut into component charts, and the individual charts might be positioned appropriately on the camera bed. Chart contrast, line dimensions, spacing, and other characteristics are defined by ANSI/AIIM MS51. See figure 13, figure 14, and figure 15 of this standard (MS23).

NOTE – Photocopies of charts should never be used because they are not as precise as the originals.



NOTE — This figure is for illustration only and can not be used for test purposes. See ISO 3334.

Figure 12 — ISO Resolution Test Chart No. 2

6.1.17 White reflectance patch

Bright white patches, which reflect approximately 90 % of the light, are quite useful for monitoring the consistency of a microfilm camera. The patch can be made of paper, plastic, cardstock, or ceramic tile. Because maintaining consistent whiteness or reflectance is critical to good process control, the material should be either able to be cleaned or inexpensive enough to renew when it becomes soiled. As a process control technique, the patch is photographed at the beginning and end of all reels. After processing, the density of each patch is measured and the information is used to evaluate the camera variability within a reel and the total system (camera/film/processor) variability between reels. An exposure level that provides a density between 1.00 and 1.20 is suggested. See 8.5 for more information about density control.

6.1.18 A 50 % reflectance patch

When photographing resolution test targets, the camera operator must decide which exposure level to use. There are three techniques, and each has the potential of creating slightly different test results. One method is to expose the test target at the exposure level being used for documents being filmed. Another is to expose them so the test charts end up with approximately the same background density as documents being filmed. A third alternative is to photograph the charts along with a 50 % reflectance patch at an exposure level that will yield a density between 1.00 and 1.20. This method provides a standard for conducting the test, and the 50 % reflectance patch acts as a reference tool.

6.2 Inspection equipment and supplies

See figure 16.

6.2.1 Microscope

A microscope is an optical viewing device used to magnify and evaluate microfilm images. A high-quality microscope is indispensable for determining microfilm system resolution.

NOTE – Microform viewers can **not** be used to evaluate resolution test targets.

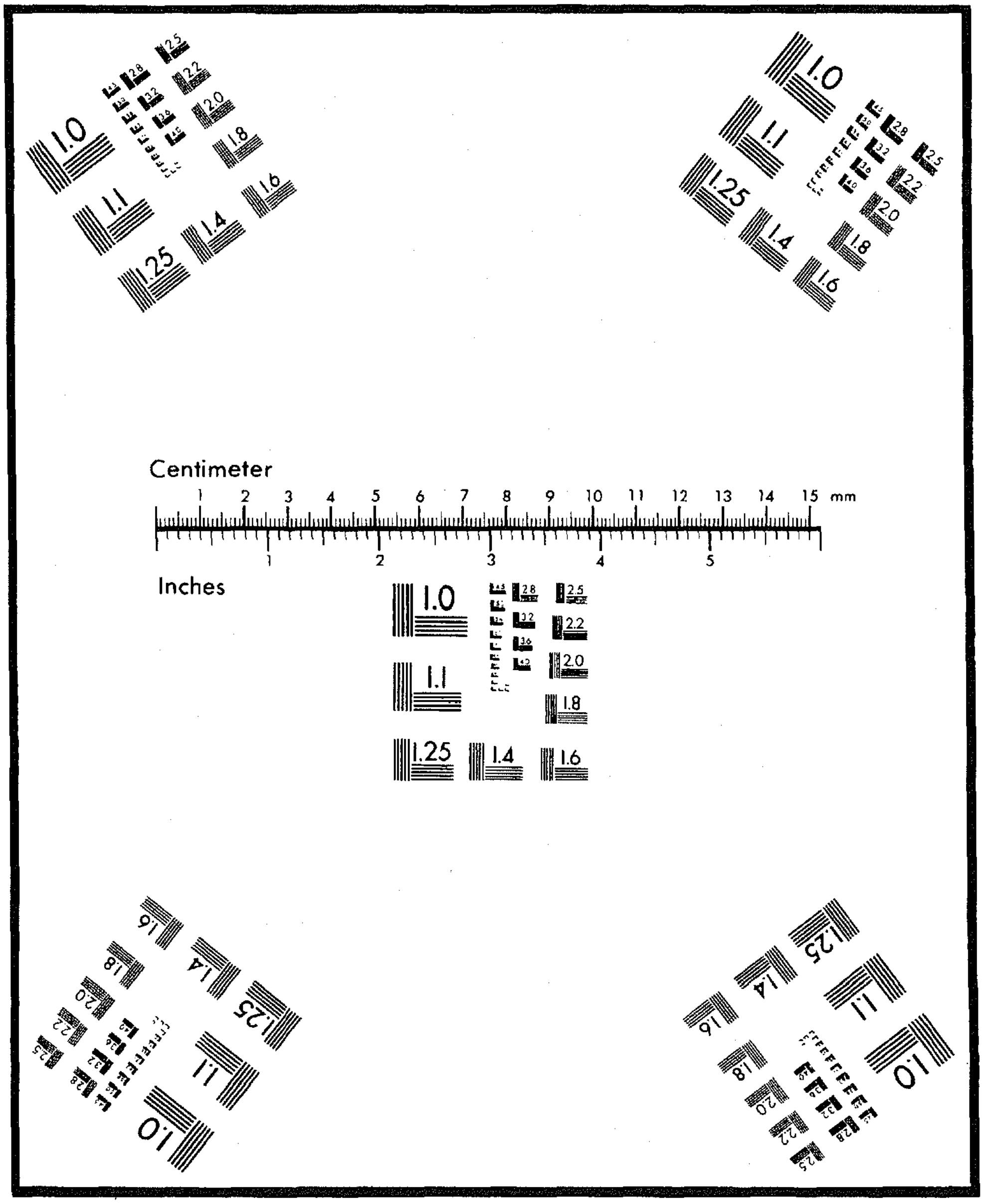
Sophisticated microscopes offer a choice of magnifications. The rule of thumb for choosing microscope magnification is to select a magnification 1/3 to 1 times the anticipated microfilm resolution. (See ANSI/AIIM MS51, ISO 3334.) For example, if the anticipated resolution is 120 lp/mm, the magnification of the microscope should be between 40X and 120X. Because 75X and 100X magnification level microscopes are readily available, either is an excellent choice for most microfilm applications.

All microscopes have two types of lenses: eyepieces and objectives. The eyepiece is the lens closest to your eye when viewing and is generally marked "10X" or "20X". The objective is the lens closest to the film when viewing and is commonly marked "4X", "7.5X", "10X", "20X", or "40X". The magnification of a particular combination of eyepiece and objective lenses is determined by multiplying the numbers on both lenses. For example, on a microscope equipped with a 10X eyepiece lens and a 10X objective lens, the total magnification is 10X times 10X or 100X.

Two basic types of instruments are available: shop microscopes and scientific microscopes. Hand-held, monocular shop microscopes are compact, lightweight, and portable, and they require a separate light source. These hand-held devices are manually positioned overtop of stationary film stretched out horizontally over a light-box. Shop microscopes are ideally suited to laboratories where such equipment will receive only occasional use.

More-expensive scientific microscopes offer several objective lenses arranged in a rotatable turret, self-contained light-source, and they are available with monocular or binocular eyepieces. Because both eyes are used with binocular microscopes, they permit extended viewing with minimal eyestrain. Binocular microscopes are ideally suited to laboratories that perform a large number of resolution evaluations. Many scientific microscopes have slide glass holders as standard equipment, which should be removed from the stage to minimize film scratching. When in use, the microscope remains stationary and the film to be evaluated is precisely positioned beneath the objective lens for viewing.

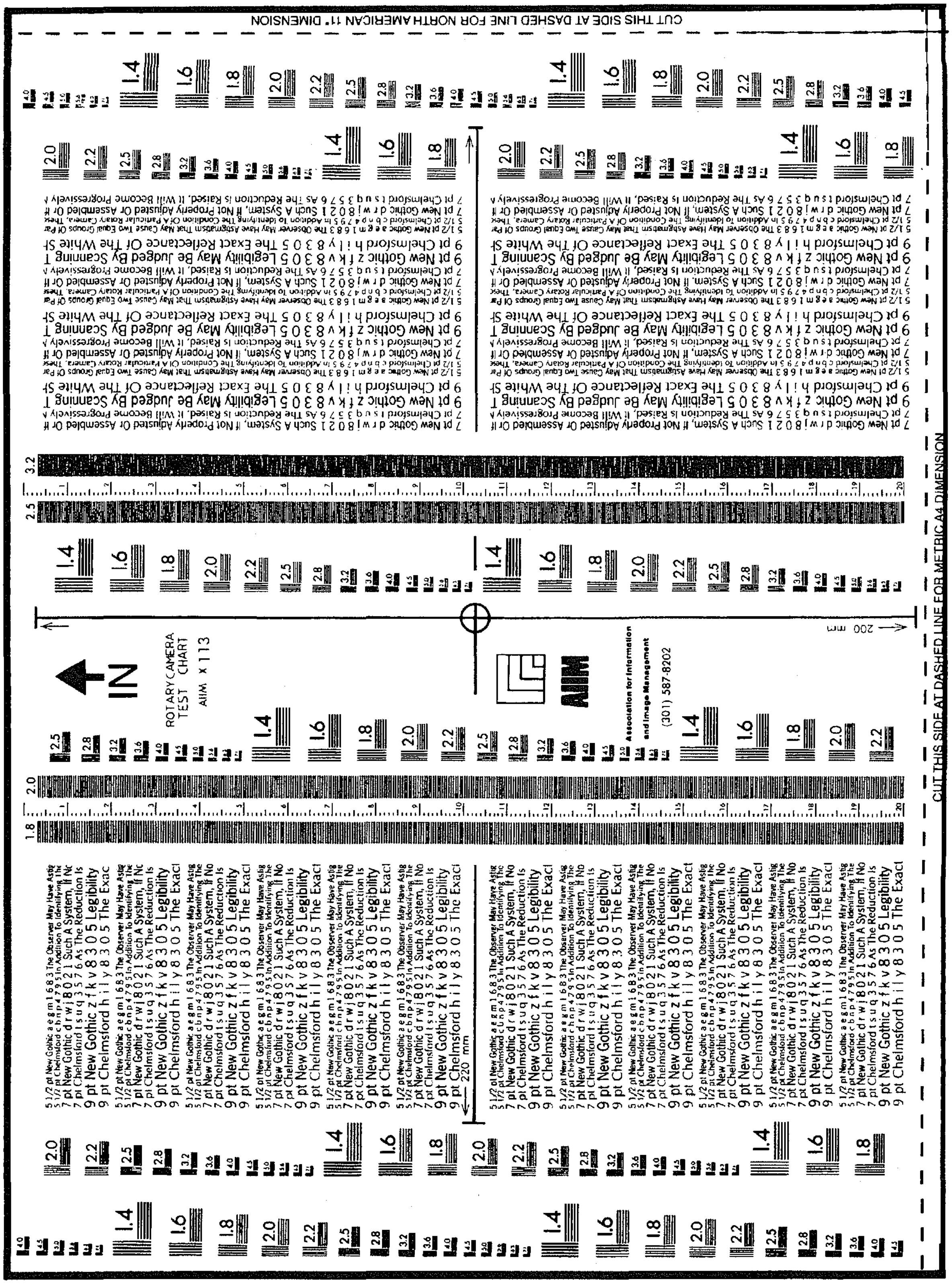
NOTE – Stereoscopic microscopes should not be used for evaluating resolution test charts.



NOTE 1 — This figure is for illustration only and can not be used for test purposes.

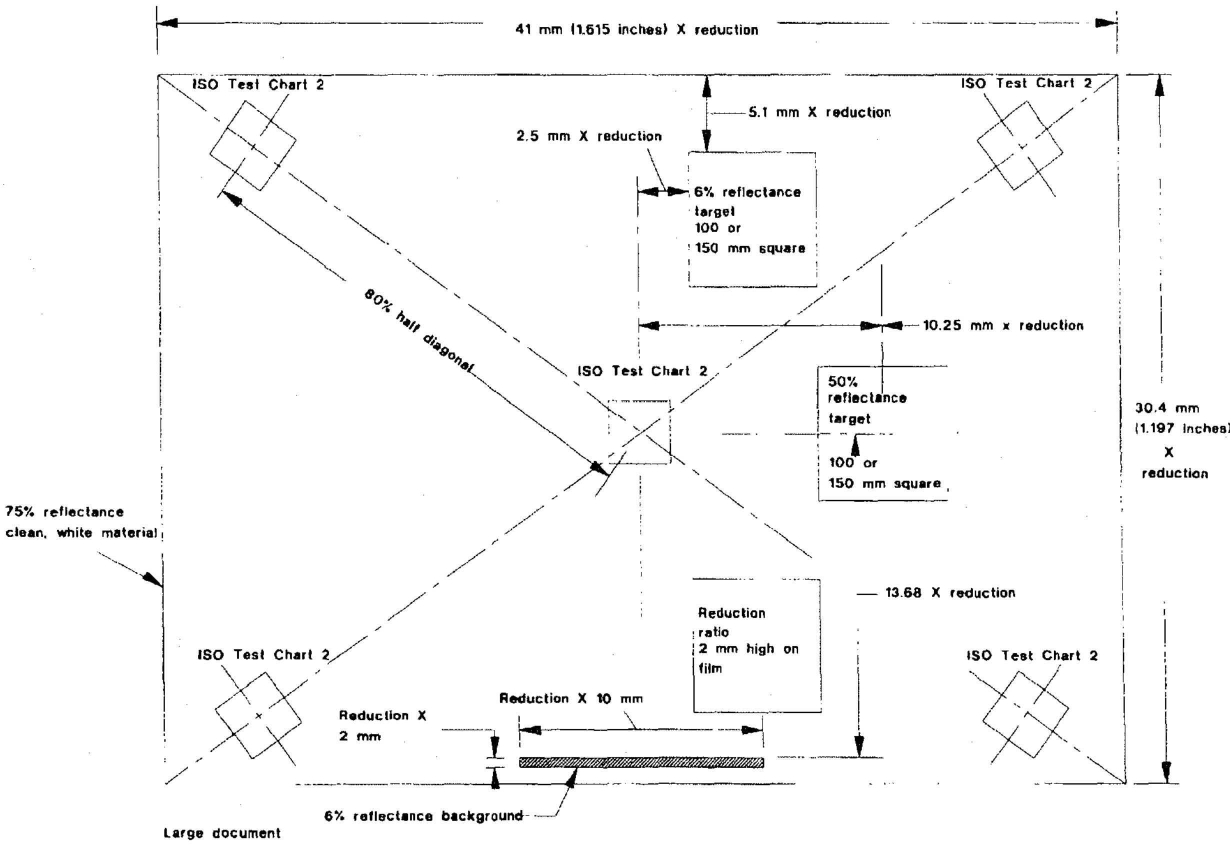
NOTE 2 — The camera test card shall be an assembly of five ISO Resolution Test Charts No. 2 or NBS and a 150 mm (6 in) paper scale, all mounted on a 215 mm × 280 mm (8-1/2 in × 11 in) piece of single-weight, white illustration board or black anodized aluminum as follows. The center resolution test chart shall be placed with the "0" of the "5.0" pattern within 3 mm (1/8 in) of the center of the test card and with the lines of the test patterns parallel to the test card edges. The corner test charts shall be positioned so that the "0" of the "5.0" pattern is within 3 mm (1/8 in) of the intersection of the diagonals of the test card and a line drawn 140 mm (5.5 in) from the center of the test card. The corner charts shall be oriented so that one edge of the chart is parallel to the diagonal of the test card. (This will require trimming the outer corners of the resolution charts.) A 150 mm paper scale showing increments of measurement in both inches and centimeters shall be located over the center resolution test chart and centered on the vertical center line of the test card. The test card shall be filmed on the same camera, at the same time, and under conditions that will achieve the same background density as the text. To assure that this procedure has been followed, there shall be no splices between the test card and the adjacent 10 frames of text. These requirements also apply to test cards at the end of the reel.

Figure 13 — The 8-1/2 in × 11 in camera test card for planetary camera microfilming



NOTE — This figure is for illustration only and can not be used for test purposes.

Figure 14 — AIIM X113 — Rotary Camera Test Chart



NOTE — See MS24.

Figure 15 — Test target — Reflectance, resolution, and reduction ratio

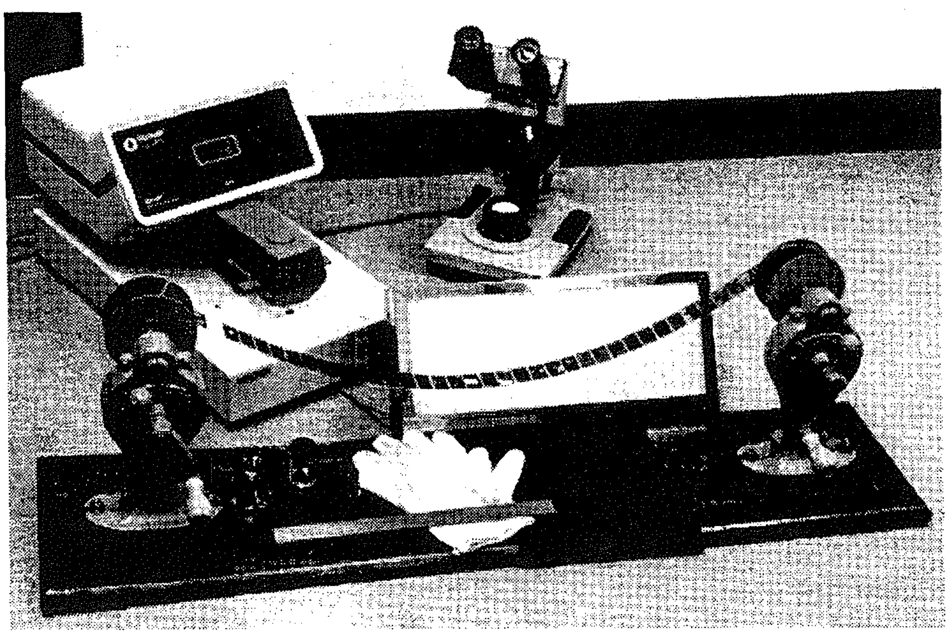


Figure 16 — Microfilm inspection equipment

6.2.2 Transmission densitometer

Transmission densitometer is a precision optical instrument that indicates the amount of light transmitted through a piece of photographic film. The densitometer measures the amount of light falling on the film and compares it with the amount that actually passes through. The ratio is converted into a number referred to as "density". The more light that is stopped by the film, the higher the density value.

Common to all densitometers is a light source, an aperture, a collector, a light sensitive device, and a readout or display. Densitometers must be kept clean. Dust that accumulates on mirrors, lenses, apertures, and photocells causes a great deal of variability when density measurements are taken. Internal components should be cleaned regularly with clean, dry, compressed air.

To accommodate variously sized images, densitometers are usually supplied with several aperture discs. Aperture diameters of 1/2 mm, 1 mm, 2 mm, and 3 mm are common. The 1/2 mm and 1 mm apertures will permit taking readings on a wider variety of image sizes. However, larger apertures will deliver greater precision and accuracy. A densitometer is only accurate to the degree to which it is properly calibrated. Supplied with most densitometers is a film patch that has been certified by the manufacturer to have a specific density.

Caution: Care should be taken with these calibration patches because the density value can be affected if they are scratched, abraded, or marked with fingerprints.

One option, as these supplied patches age, is to purchase a calibrated photographic step tablet. See 6.2.3 for more information about calibrated step tablets. Frequent calibration against such a standard will ensure long-term accuracy as well as day-to-day precision. Densitometers should be calibrated at least daily after a warm-up period and preferably again before any critical measurements are taken.

6.2.3 Calibrated step tablet

Calibrated step tablets are short lengths of photographic film containing individual segments or steps with varying levels of density. The densities range from approximately 0.05 to 3.00 in nominal 0.15 increments. General-purpose step tablets are commercially available from some film manufacturers and most densitometer manufacturers. Calibrated step tablets are available with a listing of certified densities traceable to National Institute of Science & Technology (NIST). The sole purpose for such reference material is setting up, checking, and calibrating densitometers. Clean gloves should always be worn when handling step tablets. Periodic equipment calibration to a recognized standard is the only way to maintain day-to-day stability and long term accuracy. Regular use of a clean, scratch-free tablet is key to successful process control of cameras, printers, duplicators, and processors.

6.2.4 Reader

Microform readers are routinely used to magnify the user copy microfilm product back to an original useful size for viewing purposes. Microform readers can also be used as inspection devices to evaluate camera masters and user copies. Both microfiche and roll-film readers can be useful in the micrographics production facility. It is important that the equipment does not damage the film. Cleanliness, adequate equipment maintenance, and proper operating procedures are imperative to prevent film damage.

6.2.5 Rewinders

A pair of film winders is indispensable for handling and inspecting microfilm. Options include manual and power winders with different gear ratios, spindle types and lengths, and mounting configurations. Manual winders with a 4-to-1 cranking ratio are ideally suited to handling short lengths of film on cores, spools, or reels. Using this ratio, the microfilm reel rotates 4 times for each turn of the crank. Heavy-duty winders with crank ratios of 3 to 1 or 2 to 1 require additional amounts of cranking when using spools or reels. When one is winding 1000 ft (305 m) or 2000 ft (610 m) rolls of film, however, heavy-duty winders with a lower crank ratio are desirable because they require less manual effort.

The ideal workstation for handling large rolls consists of one heavy-duty manual winder and one power winder. With this setup, film can be wound manually in one direction slowly and smoothly during inspection and then rewound at high speed by using the power winder.

Mount the winders on a portable board rather than permanently to a table. If the board is lightweight wood, stabilize it by fastening it to the table with C-clamps if necessary. Particleboard, which is significantly heavier than wood, makes a more-stable mounting surface. Recommended dimensions for the board are 14 in (355 mm) by 36 in (914 mm) with the centers of the winders being mounted 26 in (660 mm) to 30 in (762 mm) apart. Care should be taken to countersink the heads of mounting bolts so they do not damage the surface of tables or countertops. Strips of non-slip material can also be applied to the underside of the board to prevent sliding.

6.2.6 Light-box

A light-box serves as a source of diffused light for inspecting microfilm or microfiche. It can be used with or without a hand-held magnifier to detect and evaluate most defects including scratches and density, contrast, and focus conditions.

Light-boxes or transparency viewers are normally equipped with fluorescent lamps. However, many people find that incandescent lamps provide a quality and intensity of light that is less fatiguing to the eyes. Covering unused portions of the box with black opaque paper can also cut down on the amount of extraneous light entering the eyes.

6.2.7 Specular light source

Positioning a small-filament high-intensity quartz halogen lamp as high above the inspection station as practical will provide a source of specular light for the inspector. Such light casts strong, well-defined shadows, and viewing the film surface with specular light makes mechanical defects such as scratches and abrasions easy to detect.

6.2.8 Black cloth or paper

Another technique for detecting scratches is viewing the film towards a matte black surface. The film should be illuminated by a light source from behind. A small section of black cloth or paper or of matte black art board works well as the viewing surface. See figure 17.

6.2.9 Eye loupe

An eye loupe is a hand-held magnifier that can be used for evaluating and inspecting microfilm images. They are available in various magnification levels or powers starting at approximately 5X and going up to 25X and beyond. Low-power loupes permit viewing larger film areas than do high-power loupes. The detail, however, will appear smaller. Conversely, high-power loupes will produce larger detail, but less of the image area can be seen. High-powered loupes can cause a greater degree of eyestrain when used for extended periods of time. When selecting an eye loupe, quality-related factors of concern include

- — distortion of horizontal and vertical lines;
- — colored fringes surrounding text;
- — difficulty in finding a comfortable eye position;
- — difficulty in bringing the image into focus;
- — selected areas that are out of focus.

6.2.10 Metric ruler

When trying to determine the source or cause of a repeating mechanical defect from a roll of film, measure the distance between defects with a metric ruler. Working in units of millimeters is significantly easier than working in units of inches because the calculations involve whole numbers rather than fractional inches.

Example: You notice that nicks occur on the edge of a film. Measuring the space between nicks with a metric ruler, you determine they are consistently 239 mm apart. Using the formula *circumference = pi times diameter*, divide 239 by 3.1416 (*pi*) and arrive at 76.2 mm. Converting the 76.2 mm back to inches indicates that one should search the microfilm production area for a rotating object 3 in in diameter. A damaged 3 in roller in the processing machine is a likely problem area. Every time it rotates, it nicks the edge of the film.

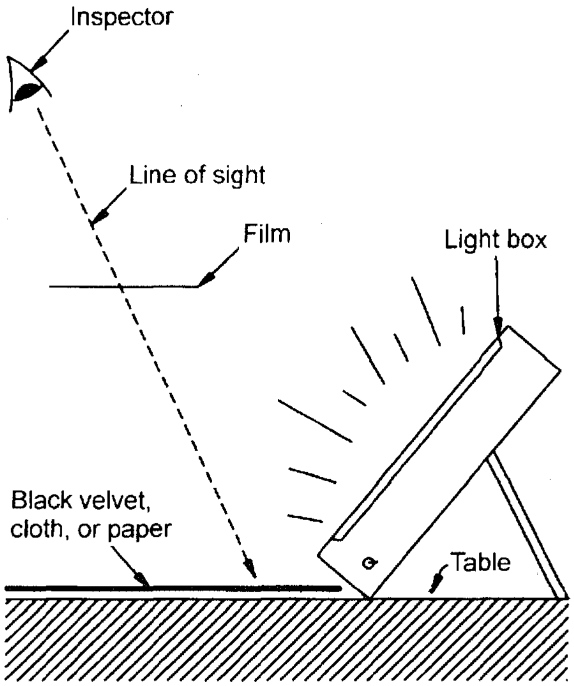


Figure 17 — Inspection using black cloth or black paper

6.2.11 Gloves

Gloves for use around photographic products are available in either cotton or nylon. Gloves provide inexpensive prevention of film contamination due to fingerprints. Because cotton "breathes" and wicks away perspiration, it tends to be more comfortable than nylon. Cotton gloves come in a variety of quality levels, and the protection offered to the film, comfort, and fit are directly related to price. See 6.1.13 for laundering instructions of wipers, which also apply to gloves.

6.3 Post-production equipment and supplies

Equipment and supplies covered in this standard include enclosures, splicing tape and photosensor tape.

6.3.1 Microform enclosures

The word "enclosures" is expanded here to refer to all items that are used either in direct contact or close proximity to microfilm while in storage. Enclosures can include

— cardboard microfilm boxes;
— film cans;
— plastic film boxes;
— microfiche envelopes;
— microfiche jackets;
— aperture cards;
— cartridges;
— splicing tape;
— spools;
— reels;
— plastic cores;
— fiber cores;
— film-anchoring wedges;
— elastic bands;
— string and button ties;
— vinyl strips;
— banker boxes;
— inks;
— adhesives;
— labels.

Enclosures should be made of materials that meet certain chemical and photographic criteria as discussed in 6.3.1.1.

6.3.1.1 Photographic inertness

If LE 500 and LE 100 films are to be stored with the above enclosures, know what effects, if any, the enclosure materials will have on film. These materials must be photographically inert and must not in any way harm the silver image. Such determinations can only be made by conducting a Photographic Activities Test on the material in question. See 6.3.1.2 for more information about the Photographic Activities Test and ANSI IT9.2 for more information about filing enclosures and storage.

6.3.1.2 Photographic activities test

At present, the only way to determine an enclosure's degree of safety is to conduct a Photographic Activities Test. This test measures the chemical effects of unknown materials on very sensitive colloidal silver material. Conducting the test at elevated temperatures and humidities accelerates any harmful reaction. See ANSI/NAPM IT9.16 for more information about the Photographic Activities Test. Each piece of equipment in 6.3 that provides an enclosure should pass the Photographic Activities Test.

6.3.1.3 Plastic reels

Plastic microfilm spools and reels are commonly used to contain 16 mm and 35 mm roll microfilm and are generally made from polystyrene. They should be free of mold-release agents, and plasticizers because these can accelerate silver microfilm deterioration.

Reel dimensions and tolerances should conform to ANSI/AIIM MS34. The width of the slot into which the film is inserted is critical. If it is too wide, then starting the winding process can be difficult, especially with thinner-based polyester films. Polyester films tend to slip out of the slot as the reel is rotated.

Reels with square spindle holes on both sides are common and simplify the microfilm reader loading and threading steps. However, because the reels can be installed on equipment spindles in either of two ways, they can result in films being incorrectly wound. See figure 7.

6.3.1.4 Microfilm cartridges

Although cartridges for 35 mm microfilm are less popular, there are several styles of 16 mm cartridges in common use today. Cartridges provide the microfilm user with a hands-off technique of loading and threading 16 mm readers and reader-printers.

6.3.1.5 Storage boxes

Storage boxes are normally made of cardboard and are used to house open reels or spools of 16 mm and 35 mm roll microfilm. Boxes that will be used for storing LE 500 and LE 100 film should pass the Photographic Activities Test, have high folding strength and neutral pH, and be free of lignin. When determining the suitability of a storage container, all components of the box such as adhesive, inks, and labels should be tested. Thumb notches, which are cut into at least one side of the microfilm box, facilitate opening box flaps. Frequently opened boxes with a thumb notch on one side only, made of low-strength cardboard, show wear more readily than boxes with thumb notches on each side. Placing a thumb notch on both sides of the box doubles the expected life because each flap has an equal chance of being used.

6.3.1.6 Microfiche envelopes

Microfiche envelopes should be constructed of high-quality paper and glue that passes the Photographic Activities Test. Paper stock should have a neutral pH and be free of lignin. Glue used for assembling should not absorb moisture from the air (non-deliquescent) and should not react chemically with the film. Glues that absorb moisture can soften and wick through the paper stock and actually adhere to the microfiche. Ideally, envelopes should also be constructed so that the glued seam is in contact with the base side of the film. If microfiche of mixed generations is to be stored, the emulsion side of some will inevitably come in contact with the glue line. Direct contact under high-humidity conditions can lead to sticking. The surface of the paper stock should be smooth and fine. Coarse fibers could cause damage to the emulsion surface when film is packed tightly in a file drawer, especially in high-humidity environments. See ANSI IT9.2 for more information about storage conditions.

6.3.1.7 Microfiche jackets

The clear plastic materials from which the jackets are made should be tested for possible negative chemical reactions when using silver microfilm. For use with LE 500 film, jackets should pass the Photographic Activities Test.

6.3.1.8 Labels

Labels are frequently applied to microfilm boxes and cartridges, microfiche envelopes and headers, and roll-film leaders. So that the paper, adhesive, or ink does not cause microfilm deterioration, chemical makeup of labels is critical. For use near LE 500 film, labels should pass the Photographic Activities Test.

6.3.1.9 Adhesives

Adhesives used in assembling microfiche envelopes or microfilm boxes should neither absorb moisture from the air nor react chemically with film. Adhesives should pass the Photographic Activities Test. In humid environments, the glue can absorb moisture, soften, seep through pores in the microfiche envelope stock, and stick to the film.

6.3.1.10 Inks

Inks used on or near film should be tested to determine their long-term chemical effects. Inks should pass the Photographic Activities Test. Solvents used in some permanent markers have been known to completely erase vesicular images.

6.3.1.11 Rubber bands

Sulfur is added to crude rubber to provide rubber bands with elasticity and long life. Sulfur readily reacts with silver microimages to form silver sulfide. Most rubber bands, even those made from "low-sulfur rubber", will react negatively with silver microfilm and should not be used to retain film on the reel.

6.3.1.12 String and button ties

When constructed of materials that pass the Photographic Activities Test, string and button ties provide an excellent method of wrapping and protecting relatively full reels of 35 mm microfilm. Paper bands keep film from slipping on reels, which can produce scratches. Reel reference numbers on bands can act as a visual check to ensure the film is being returned to the correct container.

6.3.1.13 Vinyl strips

Small plastic tabs are available for use in holding the free end of a roll of microfilm in place. The strip is peeled off the film when the film is to be used, and it is replaced before the film is returned to storage. Infrared spectroscopy has shown that some of these tabs are made of PVC (polyvinyl chloride), plasticized with di (2-ethylhexyl phthalate). The plasticizers, used to stabilize the PVC to prevent release of corrosive hydrogen chloride gas (HCl), migrate to and concentrate on the surface of the PVC and damage anything they contact, including microfilm. Eventually the plasticizers or stabilizers are consumed, and the PVC, no longer stabilized, releases HCl as it continues to degrade. Phthalate-plasticized PVC products are unsuitable for use on silver microfilm.

Additionally, once the film's leader becomes dirty and coated with oils, vinyl strips are only marginally effective in their ability to hold.

6.3.2 Microfilm-splicing tape

See also 6.1.7.1. Although the use of self-adhesive tape is discouraged on any silver microfilm intended for permanent storage, there are times when it is unavoidable. The use of adhesive tape might be required for joining dissimilar film types that cannot be spliced ultrasonically or for attaching leaders and trailers to film cartridges.

Any tape used should pass the Photographic Activities Test as described in ANSI/NAPM IT9.16. Polyester-based tapes with acrylic adhesive are generally acceptable for use on silver film. Manufacturers of microfilm-splicing tapes should be encouraged to have their products tested for photographic inertness.

6.3.3 Opaque photosensor tape

Photosensor tape, which is opaque and occasionally reflective, may be applied to film to trip counting devices on duplicators/printers or sensing devices on high-speed reading or winding equipment. Photosensor tape should pass the Photographic Activities Test.

7 Quality criteria

Quality criteria to consider include
— density;
— base-plus-fog density;
— film contrast;
— density uniformity.

7.1 Density

Density is a numerical measure describing the lightness or darkness of a microfilm image. Dense, or dark, areas of a microfilm image are composed of extremely fine particles of metallic silver. The greater is the concentration of silver, the greater is the density, and therefore the darker is the appearance of the image.

Density values are logarithmic. An image that has a density of 0.30 will permit one half of the impinging light to pass through. An image that lets one fourth of the light to pass through has a density of 0.60. If one tenth of the light passes through, then the image has a density of 1.00; if one hundredth of the light passes through, then the image has a density of 2.00.

When photographing source documents, background density of negative-appearing images is critical. A narrow range of densities must be adhered to so that characters and lines have adequate visual and photographic contrast against their background. This ensures facsimiles of originals can be easily read and duplicated to film or paper. Producing an adequate degree of density around characters without the characters themselves either gaining density or becoming thinner is the primary goal of an imaging system.

Thin lines contained in the source documents tend to build up density on film more rapidly than thick lines. Thick black lines can tolerate significantly more exposure than thin gray lines. In order to avoid filling in or darkening the thin lines and characters, an upper density limit must be identified. For most high-contrast documents, this upper density level can be as high as 1.30. As the quality or contrast of the documents deteriorates, the upper density limit must be lowered accordingly. For poorly printed, low-contrast documents (light characters on darkened paper), it might be necessary for the background density to be as low as 0.75.

Average-quality documents can generally be photographed at densities of 0.90 to 1.10. The optimum density value for a microfilm image is that which will make it most legible for reading, scanning, duplicating, or printing to paper.

It is desirable that all images on a roll or microfiche have similar text, character, or line densities so that duplication at the same exposure level is possible.

Listed in table 1 are four groups, or types of documents, along with the density ranges at which documents can be successfully microfilmed. These groupings are based on experience, but exceptions might be necessary. Most documents can be microfilmed at lower densities, but poor-quality documents might not reproduce legibly at higher densities.

A microimage will appear more readable when the contrast, or difference between the background and the information (clear) area, is high in terms of density. However, if the density is too high, fine lines and light lines from original documents tend to fill in and become gray instead of remaining clear. Thin areas (serifs) of certain characters will also fill in and become gray. Conversely, if the density is too low, graphic information will be recorded, but the lines can appear less sharp, giving the image a flat, muddy appearance. Thick, bold, black lines tend to spread when underexposed. Such images can be difficult to duplicate.

As microfilm images are made smaller by increasing the reduction ratio, the width of characters decreases proportionately. As characters shrink, they tend to build up density at an accelerated rate. Density of high-reduction images must be kept lower than density of low-reduction images. For example, a document that can tolerate a 1.20 density at a reduction ratio of 1:12 might have to be reduced to a density of 0.95 at a reduction ratio of 1:24.

7.1.1 Density table

See table 1.

Group selection should be confirmed by conducting an exposure test of a sampling of documents to be microfilmed. The test is complete only after the camera negative and the final generation that an end user will be reading have been inspected and found acceptable. These inspections include film duplicates as well as reader-printer copies.

NOTE – When microfilming documents of mixed qualities, image background densities between 0.90 and 1.10 should initially be used.

7.1.2 Base-plus-fog density

Non-image areas of first-generation camera master film should be very clear, yielding extremely low-density readings. Factors contributing density in these areas are the polyester base and any residual dyes or chemical fogging that might have taken place during processing. Although the density of the base is fixed, residual dyes and any buildup of chemical fog density can vary with conditions during development. Several contributing factors follow: excessively high developer temperatures, excessively long development times, incorrectly mixed developer, contaminated developer, and oxidized or depleted developer. The density in these non-image areas is referred to as base-plus-fog density. With modern films, base-plus-fog densities should not exceed 0.10 and are generally below 0.05.

7.1.3 Film contrast

The term "contrast" is misunderstood and frequently misused within the microfilm industry. To use the word correctly, specify whether you are describing the tonal reproduction characteristics of a particular film type or the appearance of a microfilm image of an original document.

Films that, by design, greatly expand the tones present in a document are said to be "high-contrast films". On the other hand, a film/developer combination that only moderately expands the tonal scale of the original is referred to as having "medium contrast". A film that reproduces tones on a nearly one-to-one basis or that slightly compresses the tones is said to be "low-contrast film". The level of "contrast", which refers to the film's ability to expand or compress tones, is more correctly referred to as "gamma". A particular film and development combination can be said to have "high gamma" or "low gamma", and a numerical value can be calculated that describes this characteristic.

Levels of contrast are also used to describe the appearance of microimages. Images that are primarily blacks and whites and that have few shades of gray are referred to as "high contrast". Images that contain a full range of tones may be referred to as "low contrast". The process by which such images are created is referred to as "continuous tone". A combination of film type, exposure level, type of developer, degree of development, and tones/colors contained in the document affect the level of image contrast. The minimum and maximum densities of both images can be the same, but the one with shades of gray is considered "low contrast", and the one lacking gray tones is considered "high contrast".

Contrast levels increase as successive generations are produced, and if polarity is alternated, contrast builds rapidly. For example, if the first generation in a reproduction system is negative, the second is positive, and the third is negative, then the final image contrast will be extremely high, allowing few shades of gray to remain.

7.1.4 Density uniformity

Density uniformity must be measured at several points in the microfilming process. Uniformity can be measured within a single frame or exposure, from one frame to the next, or from one reel to another. Precision microfilming generally requires that the density of a given batch of similar source documents remains within a range no broader than 0.20. In order to accomplish this, many variables must be acknowledged, understood, and controlled.

Variables that affect the density between frames and between reels are greater in number and are normally more random than those affecting densities within frames. Of the many variables that have an effect on between-frame densities, camera exposure setting has the greatest impact. With today's films, chemicals, and equipment, an exposure change of 1 V can result in a change of between 0.05 and 0.08 density units. Controlling voltage to the exposure lamps is critical. Solid state regulators and digital readout meters simplify the task of controlling and adjusting lamp output and offer a great deal of precision over older floor-model voltage regulators and dial-type meters. See 6.1.4.1 and 6.1.4.2 for more information about voltage control devices and readout devices.

Between-frame density variations can be a result of fluctuations in the reflectance of the paper being photographed. If one exposure setting is maintained, as the whiteness or color of documents changes, the resultant densities will drift accordingly. Light meters, photocells, and reflectance type densitometers are valuable when determining proper exposure adjustments. They should not, however, be used without a reasonably thorough understanding of the photographic process and definitely should not be followed blindly. The feedback provided by such instruments can lead the operator to make totally inappropriate exposure changes if the instruments are not sensing representative portions of the documents being filmed. Instruments cannot take the place of skilled, qualified camera operators. See 8.4 for additional sources of density variability.

7.2 Resolution

Resolution — or resolving power — is the measure of a microfilm system's ability to resolve and record fine detail. Variables that affect resolution include

— film;
— camera;
— lens;

— processing;
— vibrations.

The resolving power of the system directly affects the legibility of documents being filmed. As subsequent copies are made from the camera master, a resolution loss of 5 % to 10 % can be experienced for each generation.

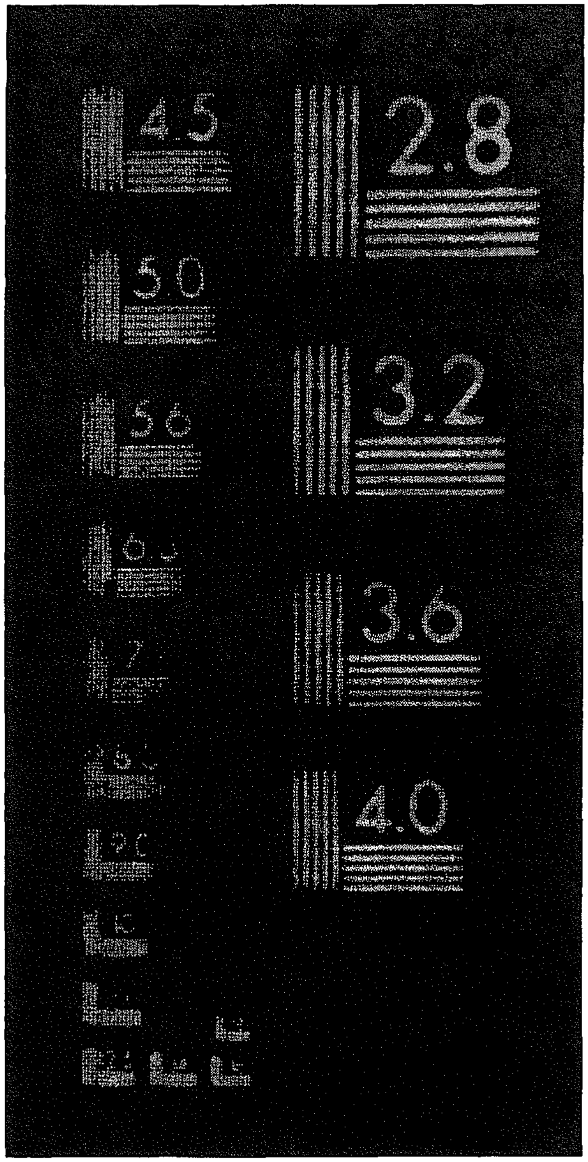
A numerical resolution value is determined by photographing an array of resolution test charts (target) in the exact same manner as the source documents. This manner involves the exposure level, the reduction ratio, whether the source document was above or below glass, and whether it was transported through automatic document-handling devices. After processing, the image of the chart is inspected with a microscope. While looking through the microscope, the inspector identifies the smallest pattern in which the five lines constituting the pattern can be distinguished in both directions. See ANSI/AIIM MS51 (ISO 3334). Variations between inspectors commonly exist. Each can differ slightly in the interpretation of a particular resolution test chart. To maintain uniformity in the interpretation of test results, inspectors should be given the opportunity to occasionally view the same chart on the microscope and compare readings. Astigmatism, an optical aberration common to many people, can impair the inspector's ability to accurately interpret resolution test charts. Corrective lenses that compensate for astigmatism should be worn while using the microscope. See figure 18 for an example of a resolution test chart. The number adjacent to the smallest resolved pattern is multiplied by the reduction ratio. This mathematical product is resolution, and it is expressed in line pairs per millimeter (lp/mm). For example, if the smallest pattern that can be discerned or resolved through the microscope is labeled "5.6", and the reduction ratio used for this image was 1:24, then the resolution expressed in line pairs per millimeter is 134 lp/mm (5.6 times 24).

When conducting a resolution test, the entire frame should be evaluated. To do so requires the assessment of at least five individual test charts, not just a center chart. It is the nature of most optical systems to not perform equally well in the four corners and the center. The center chart will normally exhibit higher resolution than the corners. Because good resolution is necessary over the entire field being photographed, the area that has the poorest or lowest resolution is the one that should be reported. When extraordinary differences among the five charts are found, the system will need further evaluation to determine the reason for the wide variation. Such problems are very elusive, and troubleshooting is best performed by trained technicians or manufacturer representatives.

One may also use the Quality Index method in 7.2.2.

7.2.1 Spurious resolution

A phenomenon that can occur when an optical system is slightly out of focus is referred to as "spurious resolution". When this occurs, some resolution patterns are so out of focus that they actually appear to come back into focus. Normally the extremely large patterns in the image of the test chart will appear to be somewhat in focus (five lines discernible in each direction), but as the inspector progressively moves to the smaller patterns, he or she might find one that appears to be more in focus than the previous larger ones. This "improved" pattern will have only four lines discernible rather than five. This is a false reading and should be a clear signal that a major problem exists with the lens focus setting. See ANSI/AIIM MS51 (ISO 3334).



NOTE — This figure is for illustration only and can not be used for test purposes.

Figure 18 — Sample photomicrograph of a resolution test chart

7.2.2 Quality Index method in general

The Quality Index chart in figure 19 directly indicates which resolution test pattern needs to be resolved in the camera master in order to provide a predetermined quality level of the smallest pertinent number or character in the document, such as a lowercase "e" in the English language. See table 4 and table 5.

Assuming the camera/lens system has been adjusted to provide maximum resolution, then the Quality Index method can be used to determine the highest reduction ratio that may be used when microfilming a specific character size to any of three different quality levels.

The Quality Index method was designed to be used with western language materials (those that use the Roman alphabet); to date the method has not been revised for use with non-Roman language materials. See 7.2.4 for the Quality Index formula.

Table 4 — Image quality

High	Image quality is considered excellent because on the final generation, all numbers and letters can be read with ease.	Quality Index 8.0
Medium	Image quality is considered acceptable because on the final generation, all number and letter characters are legible.	Quality Index 5.0
Poor	Image quality is considered poor because on the final generation, all characters are legible but the ease of reading is diminished and the clarity of subsequent reader-printer copies is poor.	Quality Index 3.6

7.2.3 Quality Index levels

There are three levels of quality that can be established using the Quality Index method. For convenience they have been classified into three general categories referred to as "High 8.0", "Medium 5.0", and "Poor 3.6". See table 4. These classifications are general in nature and based on extensive experience in evaluating film quality, and they include a subjective factor. The Quality Index numbers are derived from the pattern numbers on the NIST Resolution Test Chart 1010a (ISO Resolution Test Chart No. 2) as the minimal acceptable patterns for that index level. However, when referring to these numbers in the Quality Index or in the Quality Index formula, they are **pattern independent**. The assigned Quality Index numbers help determine the pattern of resolution necessary for your filming application. The numbers in the Quality Index and the pattern numbers are similar in that they have the same numeric values but they have totally different applications. **The two numbers should not be confused.** Figure 3 is a reproduction of a photomicrograph showing levels of microimage quality defined by different values of Quality Index. Experience with Quality Index has indicated that the legibility of characters at a Quality Index of 3.0 is very poor and generally unacceptable. Therefore, a Quality Index of 3.6 is recommended as a poor (minimal) level of legibility because all alphanumeric characters can be read with some effort. A Quality Index level of 5.0 is considered a medium (acceptable) level of legibility because all alphanumeric characters can be read without difficulty. A Quality Index level of 8.0 or more is considered to be high quality (excellent) because all alphanumeric characters can be read with ease on the final generation. It is up to the records manager to establish the quality level required on the final generation.

When microfilm is duplicated, some loss of quality is typical. To ensure that the end-user copy of a film (whatever generation it might be) is legible, the recommended pattern to be resolved on camera master must be raised based on the number of generations that will be produced. The procedure for this is described in 7.2.5.

7.2.4 Quality Index formula

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

NOTE – Again it needs to be emphasized that the pattern number and the Quality Index number are different for different applications.

$$P = Q/H$$

where:

P is the pattern number that must be resolved on the test chart;

Q is the numeric value of the desired quality (High 8.0, Medium 5.0, or Poor 3.6);

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

$$P = \textit{Resolving Power/Reduction Ratio}$$

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

Example: *P* is the pattern number that must be resolved in test chart on camera microfilm.

$Q = 8.0$ (High quality desired)

$H = 2.0$ mm (Height of lowercase "e")

$P = Q/H$

$P = 8.0/2.0$

And finally $P = 4.0$ (the pattern number to be resolved on camera microfilm).

Because the filming project will require three additional generations, the resolved pattern number must be raised three pattern numbers to 5.6.

7.2.5 Quality Index procedure

The Quality Index method uses the NIST Resolution Test Chart 1010a (ISO Resolution Test Chart No. 2) to simulate the smallest pertinent characters found in a source document (such as lowercase "e").

Using the Quality Index chart in figure 19, decide which of the three quality levels meets your project requirements; high, medium, or poor. Moving to the left from your chosen level of quality, determine the number of generations that will be necessary for your project. (Most projects will require between 2 and 4 generations.) From the generation number, follow to the top of the diagonal line. This diagonal line now becomes the reference line for the project you have just described.

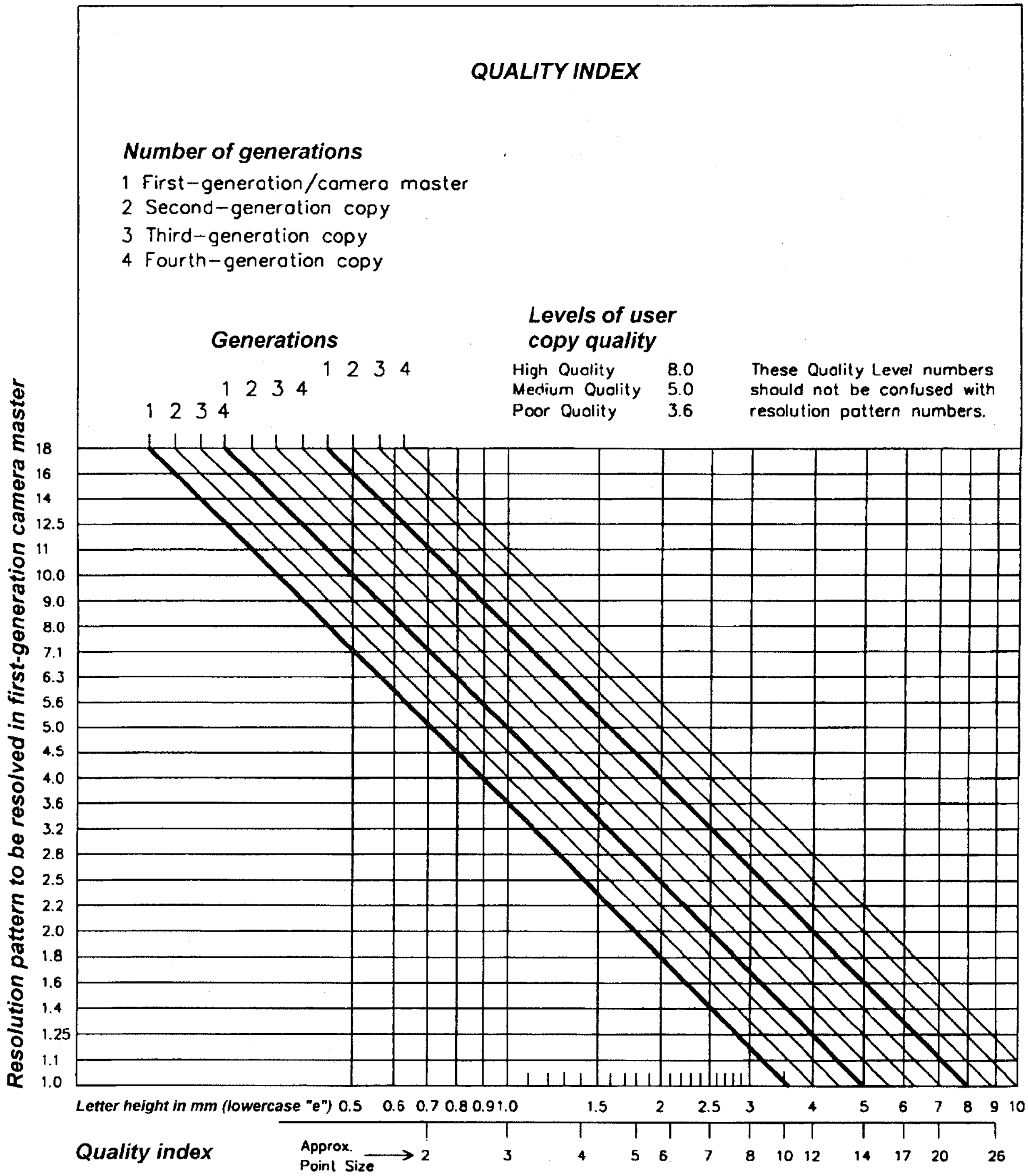


Figure 19 — Quality Index Chart

Table 5 — Resolution patterns to be resolved on first-generation camera masters when used for three generations

Height of lower case "e" on source document mm	Approximate point size	Medium quality — Smallest ISO Resolution Test Chart No. 2 pattern to be resolved	High quality — Smallest ISO Resolution Test Chart No. 2 pattern to be resolved
0.7	2	9.0	14.0
0.8		8.0	12.5
0.9		7.1	11.0
1.0	3	6.3	10.0
1.1		5.6	9.0
1.3		5.0	8.0
1.4	4	4.5	7.1
1.6		4.0	6.3
1.8	5	3.6	5.6
2.0		3.2	5.0
2.3		2.8	4.5
2.5	7	2.5	4.0
3.0	8	2.2	3.2
3.5	10	1.8	2.8
4.0	12	1.6	2.5
5.0	14	1.25	2.0
6.0	17	1.1	1.6

NOTE — Reduction ratios can be lowered (to the limit of the camera frame size) to resolve required pattern numbers.

Next, using an eye loupe with a reticle that measures in tenths of a millimeter, measure the height of the smallest pertinent lowercase "e" found in the documents to be microfilmed. When documents of different type sizes are to be photographed, the smallest type size should be used for this measurement. For example, a typical typewritten lowercase "e" is 2.0 mm high. For non-Roman text, assume the smallest character height to be 1.0 mm.

Go back to the Quality Index chart and move along the bottom horizontal line (axis) to the point that corresponds to the height of the lowercase "e". At this point, go up the vertical line to the point where it intersects your previously selected diagonal reference line. At the point where the vertical line and the reference line meet, there is a horizontal line. Move along this horizontal line to the left side of the graph to the point where it intersects a column of pattern numbers. Note the number of the resolution test pattern at the left end of this line.

The resolution test pattern number located closest to your new horizontal line represents the pattern that you must be able to "see" or resolve in the camera master to attain the predetermined quality level you desire on the final generation or user copy. If you are not able to resolve this pattern number at the particular reduction ratio you have chosen, one of the following solutions is necessary:

— the reduction ratio must be lowered;
— the lens must be better adjusted;
— an alternate production method must be used until you are able to resolve the required pattern in both directions on all five charts of the technical targets.

Following is a practical, first-person scenario of applying the Quality Index method: I desire high quality because the end user might occasionally want to make a paper copy on a reader-printer. My camera negative will be slit and then stripped up into a microfiche master. I prefer not to print hundreds of user copies directly from my stripped-up camera master because of excessive abrasions and scratches. I choose to create a second generation negative from which to duplicate. This means that the final user copies will be third generation.

The documents that I am microfilming contain many footnotes. Several lowercase "e"s that I definitely feel are important to the understanding of the text were measured and found to be 0.9 mm high.

On the high-quality line at the top of the Quality Index graph, I go left to Generation 3. I go down to the diagonal reference line. I then go to the bottom horizontal line and find the 0.9 mm point. I go up to meet the diagonal reference line and then left to find the 11-pattern number on the left vertical line (axis). This number means that on my camera master, I must be able to "see" or resolve the 11 pattern in both directions on all five of the test charts of my technical targets. If I can only resolve the 9.0 pattern, then I must make adjustments to the equipment. If I have already made certain that my lens is "perfectly" adjusted, then my only option is to lower the reduction ratio until my camera/lens system can resolve the 11 pattern. At this reduction ratio, my system can faithfully capture, with high quality, letters that are 0.9 mm high, and I can also produce third generation copies that will probably be capable of producing acceptable reader-printer copies as needed.

If, because of film width limitations of the strip-up process, I cannot lower the reduction ratio enough to be able to resolve the 11 pattern, then I must either produce only two generations and print directly from my camera master (in which case the possibility of scratching my original camera master increases) or be content with medium or poor quality.

7.2.6 Limitations to Quality Index

The Quality Index method best applies to high-quality documents; however, various document qualities should be considered. The Quality Index method does not consider 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; or line densities, widths, and spacing.

Color, in either the print or the background of the document, can adversely affect legibility of the microimage. The tonal characteristics of the original microfilm should also be considered because use of lower-contrast camera and duplicating films can improve legibility. Documents with color should be filmed with suitable densities to achieve quality reproduction. Actual camera and duplication testing is recommended when unusual document characteristics are encountered. Poor-contrast documents require High-Quality Quality-Index filming levels. Density can also affect the shape of the characters because densities that are too high can result in the loss of fine or faint lines on subsequent generations. A background density that is too low can cause bold, black lines to spread, resulting in less sharpness and poorer legibility in subsequent generations.

7.2.7 Reduction ratio

The reduction ratio, which is a measure of how many times the document is reduced in size, is specified prior to beginning any microfilming project. In some applications, the specified reduction ratio must be adhered to closely.

All cameras, rotary as well as planetary, have a scale or mechanism for indicating approximate reduction ratio. The calibration of these scales should be verified occasionally by actual measurement. To accurately determine reduction ratio, measure the height of a page on the film with an eye loupe calibrated in millimeters. Measure the same dimension of the actual microfilmed document (in millimeters). Divide the larger number by the smaller number; the result will yield the reduction ratio. For example, if the height of a document is 277 mm and its image on film is 11.5 mm, then the reduction ratio is 277 divided by 11.5 or 1:24. Any line or object of known length can be used to calculate reduction ratio. See 4.16 for more information about reduction ratios.

7.3 Physical/chemical characteristics

In addition to photographic characteristics, the physical and chemical condition of the film is critically important for reproducibility and longevity. Physical defects can occur at any point in the exposing, processing, or inspection steps. Film is very fragile and must be handled with care from the time it is loaded into the camera until the time it is stored in a secure, climate-controlled area.

7.3.1 Scratches

Scratches are a common form of physical damage and generally occur when the film is moved over an abrasive fixed surface. The emulsion (dull) side, being composed of soft gelatin, is particularly vulnerable. Scratches on the emulsion side of the film will show more readily on duplicates than scratches on the base side. The printer/duplicator exposure system plays a significant role in determining whether a particular scratch will show on a duplicate copy. If the light source of the duplicator/printer is heavily diffused and relatively close to the film, fine base-side scratches will not show objectionably. An extremely diffused light source, however, diminishes resolution. If the printer/duplicator has a collimated or specular light source, with light rays traveling nearly parallel, they will cast sharp, well-defined shadows of even the finest base-side scratches. Scratches might show objectionably on the duplicate; however, resolution loss will be minimal.

No rules govern the appearance of scratches on subsequent generations. However, a scratch in the clear area of a camera master will often divert the light rays (cast a shadow) and prevent the light rays from reaching duplicate film. As a result, the image of the emulsion-side scratch on reversal films will appear to be underexposed or lighter than the surrounding area. On non-reversing films (direct duplicating films), the image of the scratch will be underexposed or darker than the surrounding area.

Wax and plastic coatings might prevent minor scratches or fill in existing scratches; however, such coatings are not approved for use on LE 500 films. See ANSI/NAPM IT9.1.

7.3.2 Gouges

Scratches that penetrate the emulsion layer and actually remove image silver are referred to as "gouges". These areas have very low density, will transmit light from the duplicator, and will produce an exposed mark on the next generation. Images of gouges located in the camera master are generally black on reversal films and clear on non-reversal films.

7.3.3 Rippled edges

Rippled or scalloped edges can result from excessive or uneven tension when the film traveled through a deep-tank processing machine. When film is being pulled with great force, it can track strongly to one side and be forced to ride up the side flange of the rollers. Bending the edge of the film in this way causes it to be permanently warped. Rippled edges will interfere with good emulsion-to-emulsion contact when making duplicates.

7.3.4 Nicked edges

Broken, cracked, worn, or defective rollers in a processing machine can cause nicks in a film's edge. Normally nicks are caused by a blow to the edge of a roll of film with a sharp object. If severe, the nick could become the site for future tearing of the film.

7.3.5 Water spots

A droplet of tap water permitted to dry on the film will often result in a spot. The amount of residue contained in the spot is directly related to the mineral content of the processor wash water. When properly adjusted, squeegees, vacuums, rotating brushes (slingers), and air knives are effective in removing surface water. When processors are operated at very high speeds, several consecutive water removal devices might be needed to prevent water spots. As a last resort, a water wetting agent (such as Kodak Photo-Flo Solution™ or the equivalent) may be added to the final submerged wash tank. This effect causes water droplets to disperse and creates a uniform layer of water, which minimizes spotting.

NOTE – Softening water does not remove minerals; it simply replaces the calcium and magnesium ions with sodium ions. The use of soft wash water can swell the gelatin and make it more susceptible to mechanical damage.

7.3.6 Residual compounds

Silver microfilm is highly reactive with many chemicals. It is important that all undesirable compounds or by-products be removed from the processed film.

7.3.6.1 Residual photographic chemicals

When processing microfilm, the purpose of fixing is to remove any silver halide that was not used to create images. If the fixer solution is chemically weak, if it contains an excessive amount of dissolved silver, or if the film does not dwell in the fixer long enough, then the film will not be totally "fixed" and will contain a high residual amount of unwanted ionic silver and thiosulfate ion. In an extreme case, the film will look milky after processing. This unwanted silver can, in time, discolor and cause yellowish stains to appear in the clear areas of the film. The problem of residual silver can be prevented by

- using fresh, properly mixed and replenished fixer that contains an adequate amount of ammonium thiosulfate;
- allowing the film to dwell in the fixer for an adequate length of time;
- keeping the silver concentration down at verified acceptable levels, generally thought to be under 1 g/l.

A general rule for determining adequate fixing time is to allow the film to dwell in the fixer for twice the time it takes to clear the unexposed silver halide.

To test for clearing time, agitate a short length of film in the fixer and note how long it takes for the milky looking silver halide to dissolve. Twice this length of time is considered adequate for complete fixing. For example, if it takes the fixer 12 s to dissolve the milkiness from the film, the film should be allowed to remain in the fixer for a minimum of 24 s.

If the length of time the film spends in the fixing bath cannot be controlled, the fixer concentration should be adjusted so that the film clears in half the available time. As another example, if the film is in the fixer for a total of 34 s, and if the film does not become clear before it is half way through the tank (in 17 s), then the fixer concentration might need to be increased.

During the fixing process, ammonium thiosulfate, along with other chemicals, is absorbed into the gelatin layer of the film. For maximum permanence, the quantity of these chemicals should be reduced to an acceptable level by thoroughly washing with water. It is, however, neither necessary nor desirable to completely remove all the thiosulfate compounds. Trace amounts left behind in the film have been shown to be beneficial in the prevention of microblemishes. See 9.3.2 for information about testing for residual chemicals and 16.3 for information about microblemishes.

7.3.6.2 Residual film dyes

Dyes are commonly used in film manufacturing. Anti-halation (AHU) dyes are added to minimize the bouncing around of light rays within the film. Such stray light negatively affects contrast and subsequent resolution of the microimages. Sensitizing dyes are added to the emulsion layer to enhance the film's sensitivity to certain colors of light. Other dyes are added to act as filters to prevent unwanted ambient light from fogging the film during loading, threading, and processing.

Dyes are normally removed in the processing operation. However some are more tenacious than others. Under certain processing conditions, residual color can remain in the film. Camera films can be particularly difficult to make colorless and will occasionally have a pink cast after processing. Although this coloring does add slightly to the base-plus-fog density, it normally doesn't present a problem when creating duplicates.

Residual dyes are the result of a combination of processor variables including solution temperatures, fixer concentration and freshness, pH of the fixer (degree of acidity), wash water temperature, and duration of washing.

NOTE – If significant quantities of direct duplicating film are processed, the red film dye can build up in the developer to intense levels. Other films that are subsequently processed in this highly colored developer can absorb some of the dye and appear pink after processing. If this occurs and is found to be aesthetically objectionable, the developer must be either totally discarded or partially replaced with replenisher that has been diluted to working strength. Heavy accumulations of red dye can inhibit developer activity and reduce subsequent film densities. The undesirable effects of processing large quantities of direct duplicating film can be minimized by increasing developer replenishment rates or by installing a dye-removing water bath prior to development.

7.4 Editorial characteristics

7.4.1 Completeness

One main reason for microfilming is to store and preserve textual or graphic information; therefore it is important that all documents or records to be preserved are accounted for and microfilmed in correct logical sequence. Unfortunately, complete and accurate document preparation prior to filming does not guarantee that the finished product will be complete and accurate. Because even properly collated sets of documents can become disordered prior to or during filming, some degree of inspection will always be necessary. As sheets or pages are being turned, two or more can stick together; if break periods or other interruptions disturb the filming routine or operator's concentration, some documents can be filmed twice while others can be overlooked.

Image continuity adjacent to all splices should be thoroughly checked because the possibility of error is increased where defective images have been edited and corrected or previously missing sections have been spliced into the finished product. Splices within a roll are to be avoided whenever possible. Only an inspection of the magnified images on a reader will permit the inspector to count pages and check for sequencing errors.

7.4.2 Targeting

When targeting, all material should be positioned consistently with document placement and should correctly describe and identify facts, circumstances, and conditions.

8 Photographing the documents

8.1 Environment

To achieve a maximum yield of high-quality micrographic images, it is important that the camera be operated in a controlled environment. In addition to restricting food, drink, and smoking in the camera area, give consideration to the following details:

— vibrations;
— power source;
— relative humidity;
— temperature;
— ventilation;
— ambient lighting.

8.1.1 Vibrations

At the time of exposure, all components of the micrographic system must be perfectly motionless. (Flow, or rotary, cameras are an exception here. With this type of camera, the exposure is made while the document and the film are moving through the camera. See 6.1.1.2 for more information about flow or rotary type cameras.) If either the document being photographed or the camera is vibrating, focus problems (blurring) can occur on the resultant image.

Vibrations can come from a variety of sources. The building in which the camera is housed can be caused to vibrate by nearby heavy truck traffic, the rumble of nearby jet aircraft engines, train and subway traffic, large electric motors such as those used to operate air conditioners, air handling units and generators, elevators, and nearby construction activities. Vibrations can also originate inside the camera itself as various mechanical components cycle for the purposes of opening and closing the shutter, advancing film, or actuating the vacuum bellows.

Unless vibrations are severe, only small characters and thin lines will be negatively affected. The effects can be intermittent and can actually go unnoticed until resolution tests are conducted with the appropriate targets. Images of resolution targets that are exposed while the system is vibrating will frequently contain line patterns that are blurred in only one direction. Depending on the direction and complexity of motion, target patterns will be affected in various ways.

An effective method of detecting camera vibration is to place a shallow tray of water atop the camera head and shine the beam of a flashlight or laser pen onto the surface of the water at approximately a 45° angle. The beam of light will be reflected off the water onto the ceiling. If the light-source is held perfectly steadily, any motion of the camera will be transferred to the water's surface and will cause the spot of light on the ceiling to vibrate accordingly. If vibrations that affect the resolution are encountered, the source must be eliminated, the camera must be equipped with dampening devices, or the camera must be relocated.

8.1.2 Power source

Provide adequate and consistent electrical power to the microfilm camera. Each camera should be on a separate, dedicated electrical circuit and ground that can be traced to a breaker panel. Providing such isolation will help ensure that the power draw from adjacent cameras and other equipment will not affect camera exposure lamp output.

In addition to providing an adequate source of power, it is desirable to install a constant voltage regulator. Such modern solid state devices filter out voltage fluctuations and provide extremely precise control of power to the exposing lamps.

Intermittently, the incandescent lamps on some planetary cameras can "blink" or fluctuate slightly near the time the exposure switch is actuated. This is normally not a problem because it does not occur while the camera shutter is open. This electrical phenomenon is elusive and not easily remedied.

8.1.3 Relative humidity

Raw photographic film is produced, packaged, and in some cases sealed in a 50 % to 60 % relative humidity environment. During manufacturing, maintaining a constant humidity provides for uniform evaporation and drying rates of water-based coatings. It also contributes to film flatness and to subsequent higher resolution in the camera. Even though most camera films have specialty coatings for the prevention of static discharge marks and static clinging, the problems normally associated with low humidity are additionally minimized if moisture is added to the environment during the dry, heating season. Paper documents being photographed are easier to jog, shuffle, turn, and stack with an adequate level of moisture in the air. Likewise, air should be conditioned (dried) during the humid season.

8.1.4 Temperature

As with relative humidity, the temperature of the workplace can affect the comfort level, affecting the performance of the camera operators. Incandescent camera lamps and old style, floor model voltage regulators or transformers generate a significant amount of heat. When several cameras are being operated in close quarters with low ceilings, the temperature can rise to an uncomfortable level.

8.1.5 Ventilation

Normal handling of documents in a camera room generates paper dust. Such airborne dust has not been found to create health-related problems, but it eventually lands on the topsides of lenses and mirrors, diminishing contrast and resolution. Airborne mold from improperly stored documents, deteriorating documents, or both can pose respiratory problems for certain individuals. The effects of dust and mold can be controlled with proper filtration, ventilation, and frequent and thorough cleaning.

8.1.6 Ambient lighting

It is highly desirable to maintain low ambient light levels in a camera room. Even with exposure lamps turned off during camera loading or unloading, high levels of room lighting will increase the possibility of fogging the edges of the film. In addition to fogging film, excessive ambient lighting can contribute enough additional illumination to the illuminated documents to increase image density. Any increase in density, however, will not be consistent because of occasional operator shading and intentional exposure level changes.

8.2 Camera setup

In addition to the basic photographic parameters of density and resolution, the operator or technician has control over numerous other factors such as the following:
- lighting balance;
- reduction ratio;
- focus setting;
- depth of field;
- depth of focus;
- exposure setting;
- automatic exposure control;
- image format;
- image spacing;
- leader/trailer;
- image retrieval aids.

8.2.1 Lighting balance

One frequently overlooked variable, which is easy to measure and monitor, is camera lighting balance. Camera lamps should be positioned so that they produce uniform density on the film. Unbalanced camera lamps can easily account for 0.20 of the 0.30 density variation allowed for precision filming. Density uniformity should be checked frequently by photographing a large sheet of uniformly white paper or cardstock. Such tests will indicate whether the lamps are aging at different rates or have been accidentally moved from their correct position. See 8.4.1 for more information about camera lighting balance.

8.2.2 Reduction ratio

Microfilm cameras are designed to operate within a range of reduction ratios from as low as 1:5 on some 35 mm planetary cameras to as high as 1:50 on some 16 mm and 105 mm cameras.

Changing the distance between the camera head and the document being filmed controls reduction ratio. Increasing this distance raises the reduction ratio and makes the film images appear smaller. Decreasing the distance lowers the reduction ratio and makes the images appear larger. Various mechanical means are used for raising and lowering the camera head. Although some cameras have motorized mechanisms, most are manual. The operator must position the head at a specific point, usually identified on an attached scale that lists the possible ratios for that particular camera.

8.2.3 Focus setting

For any given position of the document and film, there is only one correct position for the lens: the point of true focus. The object of precisely focusing a lens is to locate the true focus point. As little as a thousandth of an inch on either side of the specific set point will negatively affect the focus of a system. Various mechanisms have been devised for setting this sensitive aspect of camera operation. Responsibility falls on the operator to verify that the lens is positioned accurately for the chosen reduction ratio.

The only way to determine if a lens is perfectly focused is to photograph a resolution test chart through a series of finely spaced incremental lens positions and then evaluate the images with a microscope. The resolution values will be maximized only at the point of perfect focus. Lens positions above or below the true focus point will have lower levels of resolution.

NOTE – Poor-quality lenses that are perfectly focused and high-quality lenses that are not properly focused will not provide adequate resolution.

8.2.4 Depth of field

Depth of field refers to the zone in which the document must remain in order to yield acceptable uniform focus of the image. Just as there is one perfect position for a lens, there is one perfect position for the document. There is, however, a certain safety region on either side of the point of perfection, and as long as the document remains within this region during the exposure, the image will be in an acceptable focus range. The actual depth of this safety zone can be measured and is referred to as "depth of field". On some cameras, this depth can be as great as 1 in (25 mm). Using 1 in as an example, the document must not be any further away from the point of perfection than 1/2 in. Because a focus zone exists, the camera operator must be certain to keep the documents positioned within the depth of field during the exposure. This can be particularly troublesome when photographing documents in a tall stack. Because the top and bottom documents of a stack can exceed the depth of field, they can be slightly out of focus. Therefore, precision microfilming requires that only one sheet be positioned on the camera bed at a time. The camera head and lens must be adjusted so that the camera bed (document) will be at the point of perfect focus.

8.2.5 Depth of focus

Just as the distance of the document from the lens can vary and still result in an image that is in acceptable focus, there is a range of distances from the lens to the film that can vary. This extremely small range is referred to as "depth of focus". As with depth of field, this range increases with decreasing aperture sizes. Because the depth of focus on most cameras is extremely small, minor fluctuations in film position have a significantly negative impact on resolution or sharpness.

A film platen or vacuum platen is a mechanical component common to all microfilm cameras. Its purpose is to hold film tightly against a fixed opening or cutout during exposure. Any variability in the operation of the platen will result in variations in focus.

8.2.6 Exposure setting

Unless a camera is equipped with an automatic exposure control device, the operator must manually set the exposure level. Exposure is a combination of illumination and time. Either or both can be changed to produce a change in exposure. On cameras equipped with incandescent lamps, the exposure is normally adjusted by changing the voltage supplied to the lamps. Here the operator manually rotates a knob while viewing a dial or digital type voltage meter. With standard type camera films and conventional processing, higher voltages produce greater exposure levels and thereby higher image densities.

On cameras with fluorescent lighting, the exposure level is generally adjusted by increasing or decreasing the duration of exposure (time) by changing the shutter speed. With standard camera films, greater exposure levels result from slower shutter speeds, producing higher image densities.

To determine the best exposure level for a given type of document, an exposure series test should be conducted. This process involves photographing a selected, representative document using 2 V increments beginning below the estimated correct level and continuing above the estimated level. After processing, densities are measured, and the exposure that produced optimum contrast is selected.

8.2.7 Automatic exposure control

If the camera is equipped with an exposure meter or photocell, the operator must be trained to take reflectance readings only on appropriate areas of the documents. Likewise, if the metering system is automatic, the operator must know how and when to override the automatic system and make appropriate exposure adjustments manually.

8.2.8 Image format

The operator can position the documents, the camera head, or both so that the images appear on the film in either the Vertical format or the Horizontal format. Established system requirements will dictate the image format as well as the reduction ratio.

8.2.9 Image spacing

The space between images on film is determined by the size of documents being photographed, the reduction ratio, and the camera's internal film-advancing mechanism. On some planetary cameras, opening or closing the gate or mask will change the amount of film "pulled down" with each exposure. This will indirectly alter the spacing of the images.

On rotary or flow cameras, the amount of space between images is controlled by a series of document sensors and various mechanical film drive components. Adjustments to image-spacing mechanisms are best left to trained technicians or manufacturer representatives.

As mechanical type film advance mechanisms inside the camera wear, tolerances increase, and the spacing between images can begin to vary. Frame overlaps can actually occur. Certain planetary cameras are capable of being retrofitted with modern stepper type motors that precisely control image spacing.

8.2.10 Leader/trailer

Unless a camera is loaded and unloaded in total darkness, ambient room lighting will fog a certain portion of the ends of the spool. For this reason, once a camera is threaded, the fogged portion of film at the beginning of the reel needs to be advanced onto the take-up spool. The amount of film wound onto this spool becomes blank and is known as "leader".

Likewise, when unloading the camera, the film must again be advanced to prevent fogging the last few images. Several wraps of raw film around the exposed portion prevent ambient light from damaging the exposures. The film advanced onto the take-up spool after the last exposure is referred to as "trailer". Experience will quickly dictate the minimum amount of leader and trailer necessary. Generally, ten turns of a camera crank mechanism will create adequate leader/trailer.

However, if the camera master is to be used as a printing master on a duplicator or printer, it might be necessary to add several feet of additional leader and trailer to accommodate the threading path and the time it takes the duplicator to attain the desired uniform operating speed.

8.2.11 Image retrieval aids

There are several effective methods of locating and retrieving images on roll film. All of them require photographing additional images onto the film. It might be a "blip", a horizontal line, a bar code, a date strip, or an oversized number or letter. Cameras equipped with automatic coding devices will sequentially change the image marks with little or no operator intervention. With non-automated systems, the operator must remember to change the objects being photographed at appropriate times. With all types of sensing systems, the position of the mark on the film is critical. The operator must make certain that the objects remain precisely in the same location from frame to frame. For aesthetic reasons, if the retrieval aid objects being photographed are white, it is important to keep them clean and replace them if they get ragged, soiled, or tattered. See ANSI/AIIM MS8 for more information about blip marks.

8.3 Microfilming procedures

To maximize the production of high-quality micrographic products, you must establish correct filming procedures and be consistent in their application.

8.3.1 Document feeding

Methods of feeding documents to a camera vary from fully automatic with extremely high speeds to totally manual with very slow speeds. Some rotary type cameras, which are designed for filming bank checks and office documents, require only that the operator keep the feed hopper filled. Checks are automatically fed through at extreme speeds and can be photographed simultaneously on both sides.

Semi-automatic rotary cameras or cameras with manual feed trays require the operator to squarely position documents at the entrance of the feed mechanism. A sensor detects the presence of a document, and the transport mechanism moves the document through the camera, stacking it along with other previously photographed sheets. Because the document must pass through narrow channels and over several fragile surfaces, remove staples and paper clips to avoid damaging internal camera components.

Some planetary cameras have mechanical provisions for feeding documents through the exposure station using a set of moving belts and a vacuum. The camera can also be equipped with a page-turning device for filming two-sided documents. Because these cameras lack the ability to automatically correct for misaligned sheets after they have been positioned on the feed table, any documents that an operator does not realign on the table will appear skewed on film.

When filming single sheets on a standard planetary camera, the operator may mark the document location on the camera bed area with matte black photographic tape (such as 3M Type 235 or the equivalent) or matte black book-binding tape. Such low-reflectance tape is ideally suited for use on camera beds and will not appear on the finished film when the camera is operated at normal exposure levels. After determining the correct document position by using the camera's alignment reticle and actually running a test, the correct location can be marked with two long pieces of black tape at right angles. If the camera bed covering to which the tape will be applied is lightweight cardstock, be certain not to stretch the tape too tightly, or you will cause the cardstock to distort.

When positioning single sheets on the camera bed, make sure they are perfectly motionless during exposure. It is not uncommon for the upper portion of a large sheet (such as newspaper) to take longer to become stationary in the field of focus than the lower portion. If the document is settling while the exposure is made, the image will be out of focus or blurred to some degree, depending on the amount of lateral movement. A technique used by some operators to minimize this problem is to slide the sheet into position with a side-to-side motion rather than positioning the sheet from above. This minimizes the amount of air trapped beneath the sheet and speeds up the settling process.

8.3.2 Microfilming bound documents

Bound pages must be held flat and motionless during exposure, requiring the use of a glass plate. A book cradle is desirable when photographing bound documents. The purpose of the glass plate, which is common to all cradles, is to hold documents as flat as possible and to keep them in the plane of focus. On some cradles, the glass plate is raised to turn the pages. On other styles, the book is lowered down and away from a fixed glass plate allowing the pages to be turned. With either type, the exposure must not be made until the document is pressed as level as possible against the cradle glass. The two must be in full, tight contact and perfectly motionless to achieve uniform focus.

Another critical operating procedure is making certain that the gutter of bound material is held as close to the glass plate as possible. Deep gutters from tight bindings are not a problem if the complete text can be pressed evenly against the glass of the cradle. If the text wraps down into the gutter, it can be obscured by the shadow cast into the gutter. If the text is printed down into the gutter and falls below the lower limit for the depth of field, the text will be out of focus to varying degrees depending on the distance from the plane of perfect focus. Spring-loaded plates on which materials are placed help compensate for gutter shadow by helping create flat image planes. Because this plate is manually raised and lowered with the turning of each page, the exposure must not be made while the plate is in motion. Doing so will result in focus problems.

Photographing bound materials presents other problems. If a camera's lights are set at abnormally low angles, the curved areas of the paper can cast shadows into the gutter. Likewise, if camera lamps are set at abnormally high angles, glossy paper can produce reflections. Normal lamp angle is 45°. However, deviations might be necessary to minimize or prevent the effects of reflections or shadows.

8.3.3 Adjusting exposure for document conditions

One of the most critical and challenging procedures a camera operator must follow is adjusting exposure level as necessary to suit conditions of the document being filmed. Although it is more expedient to photograph all documents at the same exposure level, the image contrast and final copy quality can suffer. Reflectance meters and photocells offer some assistance but must not be followed blindly. A basic understanding of sensitometry (the study of how film responds to light), is invaluable for a camera operator. It enables one to understand and visualize what happens to image contrast as exposure levels are increased or decreased.

High-contrast documents (dense black bold text printed on bright white paper) can tolerate high exposure levels and resulting high densities. Poor-contrast documents (pages with light ink on colored or dark paper) require lower exposure levels. If high exposure levels are used on low-contrast documents, thin light lines become even thinner and might not be evident on the final user copy.

The burden of learning when to change exposure, by how much, and in which direction rests with the operator.

8.3.4 Targeting

In addition to creating a continuous stream of correctly exposed images on microfilm, there might be a need to place informational targets throughout the film. The positioning of these targets is key to evaluating the film's technical quality and making the product more useful (that is, easier to identify, retrieve, and file).

8.3.4.1 Technical targets

Resolution targets, density patches, and density uniformity targets are usually photographed at the beginning and end of each reel. Resolution targets should be microfilmed in the same position (that is, vertical or horizontal) and location as the documents. For example, if a bound book is being photographed under glass in a book cradle, resolution targets should be photographed under glass as well. When creating microfiche, position of the resolution test targets should be varied so that resolution loss due to duplication equipment can be monitored in more than one location.

Although there is some controversy about how to properly expose resolution targets, the method described in most standards documents includes exposing the targets so that a 50 % reflectance patch (included in the same frame) will have a density between 1.00 and 1.20.

It is important that technical targets, especially resolution targets, be photographed along with the documents as one contiguous piece of film. So that resolution targets accurately indicate the resolution achieved during the filming of the documents, there should never be a splice between a resolution target and the documents that follow. If original technical targets must be removed, ten or more frames of documents following the technical target should be rephotographed as part of the retaken section. Such repetition of document images provides an opportunity to compare image quality before and after the retake.

8.3.4.2 Bibliographic targets

Bibliographic targets must be accurately positioned within the filming sequence. Specific applications can require specific targeting. For content, design, and location of specific bibliographic targets, refer to documents related to preservation microfilming and archival microfilming published by the American Library Association, The Research Libraries Group, Inc., and the Library of Congress.

8.3.5 Exposure timing technique

The exposure time on most microfilm cameras is quite long and with some, shutters stay open as long as one-fifth of a second. When camera operators are still developing a sense of timing and beginning to increase filming speed, they can on occasion photograph their hand. To help prevent this, position the exposure-tripping switch so the same hand feeding the document is used to trip the shutter. Once the operator develops a feel for correct timing, the switch can be situated for operator comfort to allow greater output speed.

8.4 Sources of quality problems

In addition to image contrast and resolution, there are many other factors that affect microfilm quality. Many of these are under partial, if not complete, control of the camera operator. These factors include
— camera lighting balance;
— lens limitations;
— exposure path blockage;
— camera voltage supply;
— camera lamp type;
— film sensitivity variation;
— uniformity of paper reflectance;
— proximity of reflective surfaces;
— stray light;
— latent image fading;
— densitometer variability;
— shadows;
— reflections;
— page movement during exposures;
— light fog.

8.4.1 Camera lighting balance

Unbalanced camera lamps can easily account for a 0.20 density variation within finished frames of microfilm. It is an important variable that is easy to measure. To test for light balance, photograph a sheet of clean, uniformly white paper or cardstock the same size as the largest document being microfilmed. For maximum test sensitivity, the density level should be between 0.70 and 1.30. A minimum of nine density readings should be taken to determine the range. A desirable range for a large document (such as a single newspaper page) is 0.10 or less; for two large pages in the 2B format, it is difficult to achieve a range narrower than 0.15. When adjusting camera lamps, it is necessary to have 10 % to 15 % more light falling on outer corners of the documents than on the center because the corners of the documents are further from the lens than the center of the documents.

A hand-held light meter or photometer will be valuable in obtaining a rough balance. Balancing camera lights involves a great deal of trial, error, and testing with white cardstock. See ANSI/AIIM MS26 for more information about illumination on planetary cameras.

The need for uniform density becomes readily apparent when one considers that some filming projects require image densities between two narrow, but realistic, limits. For example, if a contract requires that densities are between 0.95 and 1.15, and camera lights are out of balance by a density of 0.20, there will be no room for error in the filming or developing process. All the allowable variability (0.20) will be totally "used up" within the frame because of improper light balance.

8.4.2 Lens limitations

Although no two lenses are exactly alike in their image-forming properties or their light-passing characteristics, most lenses perform adequately at the center of their working field. However, when microfilming large documents at low reduction ratios, the outer corners of the documents are imaged by the outer portions of the lens. As the outer region of a lens' field of view is approached, vignetting (a sudden density falloff at the outer extremities of an image) and a decline of image sharpness will occur in the corners.

Flare, which is stray light, adversely affects the microfilm image. It reduces image contrast and diminishes system resolution. Lens manufacturers minimize the amount of stray light reaching the film by vacuum-depositing extremely thin layers of rare earth compounds onto the surfaces of the lens elements. (Rare earth coatings are derived from oxides of such rare metals as lanthanum, yttrium, and scandium.) These coatings let desirable light rays pass through but retard unwanted reflections and stray light. The inner surfaces of the metallic lens barrel are also coated with a flat black material. If either of these coatings is removed through aggressive, improper cleaning or scratching, these uncoated surfaces can allow unwanted light to eventually strike the film.

8.4.3 Exposure path blockage

If dust, dirt, fingerprints, paper particles, or fragments of film land on the surface of a lens, they normally will not show up as corresponding images on the film. The only consistent effect will be one of increased flare and decreased resolution. Depending on size, location, and darkness of the obstruction, the image density could be affected. The exposure path should be checked frequently for such obstructions. Clean, dry compressed air, a camel hairbrush, or both should be used regularly to remove such debris.

NOTE – Camel hairbrushes should not be touched to the skin because bristles can absorb oils, which transfer to lens surfaces.

8.4.4 Camera voltage supply

Solid state voltage regulators and digital readout voltage meters are readily available, and they offer greatly improved power stability to the lamps of microfilm cameras. The use of such equipment allows precision in setting and maintaining voltage to within one-tenth of a volt.

Older style dial (analog) type meters, especially ones with 2 V, 2-1/2 V, or 5 V increments, are subject to significant reading error and are difficult to precisely set, change, or adjust. When setting dial type meters, it is important to view the dial face from a 90° angle. Viewing from any other angle increases chances of misreading the meter.

8.4.5 Camera lamp type

The type of camera lamps used (quartz halogen, incandescent, or fluorescent) can affect the short-term and long-term stability of light output. See 6.1.4.3 for more information about overhead lamps.

8.4.6 Film sensitivity variation

Variation in film's sensitivity to light will manifest itself as variations in density when exposure and development are held constant. Recent improvements in emulsion and film-coating technology have resulted in greatly increased film consistency. It is uncommon to encounter significant variation in a film's response to light.

8.4.7 Uniformity of paper reflectance

All other variables held constant, the amount of light being reflected towards the lens of the camera changes as brightness or reflectance of the paper changes. Bright, white paper reflects more light and produces greater exposure levels than yellow, brown, colored, or oxidized paper. If camera exposure settings are not adjusted for reflectance variations, density variations will result on the film. Slight density variations are expected and unavoidable. When in addition to the paper reflectance levels, text or ink reflectance levels vary, the photographer should not attempt to make all documents result in the same density on the film. Doing so can cause low-contrast documents to record with such poor contrast that the camera master is difficult or impossible to duplicate. Correctly microfilming documents of varying contrast and brightness levels requires a great deal of skill. See table 1.

8.4.8 Proximity of reflective surfaces

Brightly colored surfaces, such a white lab coats or smocks, light colored walls or curtains, and low white ceilings that are near the camera, can reflect unwanted light onto documents being filmed. Such reflections can result in uneven or inconsistent density in the microfilm images.

8.4.9 Stray light

Stray light from nearby cameras can also contribute to density variations by either shining light directly onto the documents being photographed or by reflecting light off a white ceiling down onto the camera bed. To minimize these effects, place curtains or partitions between cameras.

If curtains are suspended from the ceiling, they need only come down to the height of the camera beds. Floor level gaps will facilitate air circulation and ventilation. Rigid partitions, if used, should go all the way to the ceiling. If this cannot be done, it can prove beneficial to paint the ceiling a dark color to prevent light from being reflected down onto the camera beds of adjacent cameras.

Quartz halogen lamp fixtures with adjustable metal barn doors reduce stray light as well as reflected light.

8.4.10 Latent image fading

When microfilms are struck by light, weak electrochemical changes take place to the surfaces of the exposed silver halide crystals. Once exposed to light, the crystals become capable of forming a visible, usable image during development. These invisible, yet developable images are referred to as "latent images". The relatively weak latent image begins fading immediately after exposure and continues until the film is processed. The quantity of silver (density) formed during development is partially dependent on the level of electrochemical change remaining on the crystals. The net effect of latent image fading is a loss of final image density, and depending on film type and relative humidity, it can be a significant source of density variation. In a precision microfilm operation, it should not be overlooked.

If totally ignored, latent image fading can cause as much as 0.10 density variation from the beginning to the end of a reel. For example, if it takes more than 2 h to expose a full spool of film, and it is processed soon after having made the last exposure, the last images on the reel will be approximately 0.10 density units darker than those images at the beginning of the reel.

A practical solution to latent image fade is to provide a waiting period of 8 h or more after the last exposure has been made. This will permit the last images to fade so that they more closely match the first images on the reel.

Generally, fine-grain films (films with very small silver halide crystals) are more susceptible to fading. It should be noted that fading is greatly accelerated by humidity and heat. For most microfilms, fading is most rapid during the first few hours following exposure and quickly tapers off to a negligible amount in 12 h to 24 h. See figure 20 for an example of a latent image fade curve.

8.4.11 Densitometer variability

Modern transmission type densitometers are routinely accurate to ±0.02 of absolute density standards and repeatable to ±0.01. The key to maintaining such low levels of variability is keeping the instrument's optical path clean and frequently calibrating it to a patch of film with known density. (See 6.2.3 for more information about calibrated step targets.) Ideally the density of the calibration patch should approximate as closely as possible the density level used for the most critical films being produced. For most applications, this will be a density of approximately 1.10.

8.4.12 Shadows

Objects (such as a high stack of documents; an operator's hands, head, or upper torso) can at times obstruct the camera lights and cast a shadow on the area being photographed. Images of shadows on first-generation negative masters will usually not be sharply defined and will show up only in the images as areas of lower density. They will, however, be more noticeable on subsequent generations.

8.4.13 Reflections

Reflections will result from any shiny surface (such as shiny objects on the camera bed, operator jewelry, and curved or wrinkled documents) that reflects adequate amounts of unwanted light to the camera lens. Reflections on first-generation camera master film will usually be sharply defined and located anywhere in the frame, and they will have higher density than the surrounding area. Chronic reflections coming from curved surfaces can require a realignment of the camera lights.

8.4.14 Page movement during exposure

Filmed documents must remain perfectly motionless during exposure. If a document slowly rises off the camera bed and moves towards the lens during exposure, it can still appear to have acceptable focus. If, however, the document moves across the camera bed even slightly, the resulting image could appear to be significantly blurred.

8.4.15 Light fog

Fogging from stray light usually occurs at either the camera or the processor. At the camera, the most common cause of fogging is failure to advance enough film leader through the camera after loading. Fogging can also occur by not providing adequate trailer after the last exposure is made but before the exposed reel is removed. See 10.2.1.4.2 for more information about light fog.

Occasionally a reel of film will have fog marks located randomly throughout. Common camera-related causes follow: inadvertently opening the door to the film compartment; using an improperly fitting camera door; and using light-sealing gaskets that are worn or misaligned. A less common source of fog can be worn parts creating an improperly fitting shutter mechanism.

8.5 Density control

8.5.1 Reference patches

Given a goal of producing high-quality precision microfilm, it is necessary to know the amount of variability being contributed by each component of the total micrographic system. Monitoring the variability of a camera requires that a white reflective patch be photographed (at the same exposure level) at the beginning and end of each reel and that its density be measured and plotted. An ideal standard reference patch for planetary cameras is a 4 in x 4 in (100 mm x 100 mm) white, ceramic tile. Because it can be easily cleaned with common glass cleaner, its whiteness or reflectance value remains constant. For rotary or flow cameras, a sheet of flexible white cardstock or plastic can serve as a reference material. A continuing supply of consistently white stock is critical to the success of the density control program.

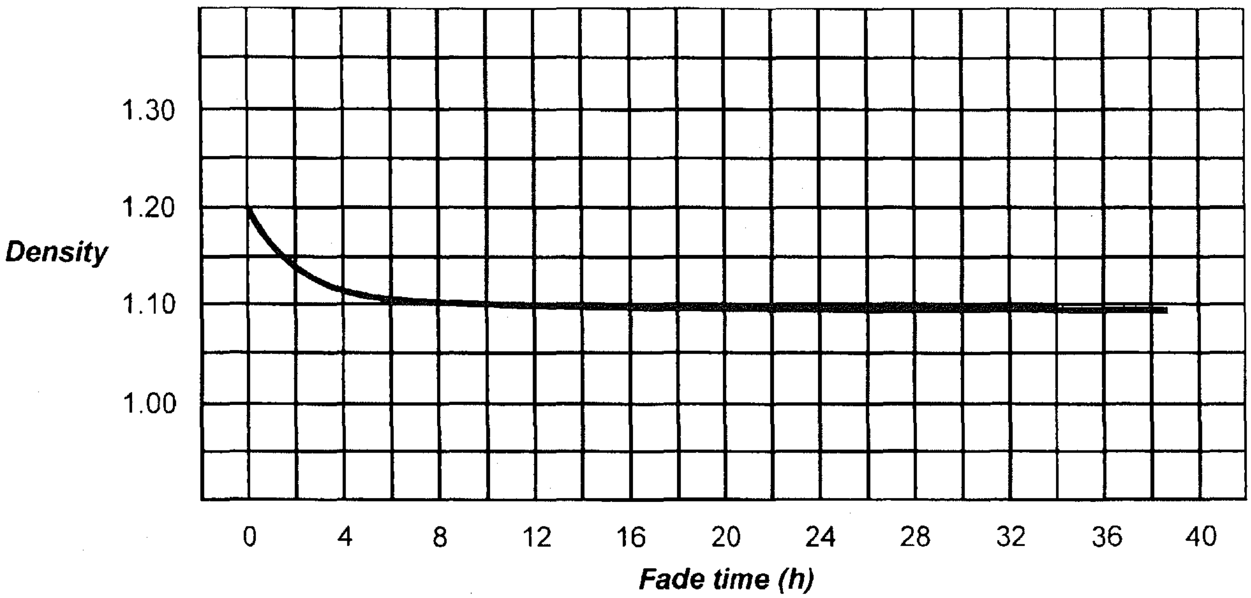


Figure 20 — Example of latent image fade curve

The control technique involves determining the exposure level at which average white documents are exposed. This level becomes the setting at which the reference material is always photographed unless the control chart indicates a necessary adjustment or there is known change in some other variable (such as raw film stock, new camera lamps, or processing conditions).

The reference material should be photographed at both ends of every reel. Although density readings are taken from all patch images, only the densities from the beginning of the reels are used for plotting purposes.

When the density values from both ends of any one reel are compared, a significant difference in density indicates one or more of the following causes:

— not waiting a minimum of 2 h between exposure and development to allow for latent image fading;
— not setting the exposure level the same for both reference patch exposures;
— not waiting for halogen lamps to regain full brilliance after having been turned off;
— voltage fluctuations;
— inability to precisely reset lamp voltage because of a coarse dial (analog) type meter;
— inherent variability in the camera or changes in processing conditions;
— variability in shutter mechanism.

8.5.2 Camera control chart

NOTE – Only the tile densities from the beginning of each reel should be used when initially setting up the camera control chart. If beginning and ending density measurements are used to establish the control chart, variations in film sensitivity are not given the same statistical weight as other system variables.

Although a variety of graph papers may be used for creating a camera control chart, the ideal paper would have 4 bold vertical lines per in (approximately 1 line per 6 mm) and 20 horizontal lines per in (approximately 5 lines per 6 mm).

After accumulating 25 density readings from the beginnings of 25 reels, calculate an average by adding up the readings and dividing by the number of readings.

NOTE – If the correct exposure level was chosen, the density values should be between 0.90 to 1.30.

The average density value is written at the centerline of the camera control chart. The centerline should be a solid line, whereas the upper and lower control limit lines should be dashes.

Using a scientific calculator, calculate the standard deviation of the 25 density values. The standard deviation should be a relatively small number (for example, 0.03). **Small numbers indicate better process consistency.** Multiply the standard deviation number by three. Add the result to the average to arrive at the upper control limit. Subtract the same result from the average to arrive at the lower control limit.

Plotted camera tile densities should remain within the control limits of the chart as long as the micrographic process (not processor) is operating randomly and normally. If plot points begin to consistently land above the upper control limit or below the lower control limit, then some variable within the process has gone "out of control", and the assignable cause must be determined and corrected. Likewise, specific trends and patterns of the plot points indicate problems and should be investigated. See figure 20 for an example of a camera control chart.

9 Processing the film

When raw film is exposed to light in a camera, the invisible latent image results. In order to convert this latent image into a visible silver image, the film must be processed. The conventional method of processing exposed silver film is to bathe it in liquid photographic chemicals called "developer" and "fixer". This method is commonly referred to as "wet processing".

9.1 Procedure

Exposed lengths of raw film are normally delivered to the processing area wound onto black plastic spools and inserted into a lighttight bag, opaque plastic box, or metal can.

Even the simplest processing machine has a particular startup procedure that must be followed and many variables that can affect the physical and photographic characteristics of the processed film. It is the operator's responsibility to be aware of, understand, and know how to control these variables. Prior to processing valuable camera film, it is wise to implement a check list of all the operating functions to determine that the processor is in good working order and capable of producing high-quality precision microfilm images.

The following is a typical checklist for a deep tank processor:

1. Check solution levels of developer and fixer in the processor.
2. Open/shut and adjust appropriate valves controlling solution flow.
3. Turn on solution recirculation pumps for developer and fixer.
4. Check pumps, valves, and lines for correct flow rates and possible leaks.
5. Check surface of developer and fixer for swirls (indicating agitation).
6. Turn on temperature controllers for developer and dryer section.
7. Check and clean rubber squeegees or wipers.
8. Check threading path to determine if machine is threaded properly.
9. Check all accessible rollers and adjust if necessary.
10. Check quantity of developer and fixer replenisher in storage.
11. Check silver recovery flow, mechanical action, current level, and the appearance of the silver on the cathode.
12. Check fixer clearing time (which should be less than 1/2 of the dwell time).
13. Check silver concentration in fixer.
14. Splice exposed film together into large rolls, if appropriate.
15. Turn on wash water and visually check for adequate flow.
16. Adjust temperature of wash water, if appropriate.
17. Open/set developer and fixer replenishment valves.
18. Check the developer temperature.
19. Process a processor control strip and a scratch test.
20. Read density of control strip; plot and evaluate it.
21. If control strip density is "in control", then load and process camera film.
22. Listen for unusual sounds from the processor while film is being processed.
23. Examine processed film for signs of scratches, nicks, rippled edges, chemical residue, and the like.

9.1.1 Conventional processing steps

Most exposed camera films are processed in a conventional manner using high-contrast, black-and-white microfilm developer and fixer. The process reverses the polarity of the original documents so that if the document has black characters on a white background, the processed camera film will have clear characters on a black background.

9.1.1.1 Develop

The purpose of the developer is to convert the exposed silver halide (latent image) into metallic silver. Greater levels of development result in more silver, causing film to have higher densities (that is, look darker).

9.1.1.2 Wash

Washing or rinsing the film with water removes the developer and stops the silver conversion process. To conserve water, some processors use a mild acetic acid solution to abruptly stop the development action. These solutions are referred to as "stop baths". They must be replenished because alkali carried over from the developer eventually neutralizes the acidic properties of the stop bath.

9.1.1.3 Fix

Fixing solutions, which are composed primarily of ammonium thiosulfate, dissolve the unconverted silver halide from the film. The silver level in the fixer eventually builds up to an unacceptably high level and must be reduced by dilution with large quantities of fresh fixer or by extracting the silver electrolytically. Extracting the silver is the only method that does not prevent the fixer from being reused in the processor.

9.1.1.4 Wash

Ammonium thiosulfate compounds left in film will eventually bleach and discolor silver images. The concentration of thiosulfate left in film must be reduced to an acceptable level. This reduction is accomplished by thoroughly washing film with water after the fixing step. The thoroughness of washing is determined by conducting an analytical chemical procedure called "methylene blue test".

Very hard water might need to be treated before being used, because it can cause inadequate washing. Excessively soft water can lead to reticulation during processing, abrasion of the film during processing, or both. Local water quality should be checked to ensure proper washing. The suggested limits on water hardness are 16 to 150 mg/l (0.9 to 8.8 grains per U.S. gallon) of calcium carbonate ($CaCO_3$). Using filters to keep dirt out of the photographic processor is required for most water supplies.

9.1.1.4.1 Washing aids

Washing aids (clearing baths), although not commonly used, help remove thiosulfate compounds from film, reducing the amount of wash water needed. Clearing baths that contain sulfite may be used to fully eliminate any last traces of halation or sensitizing dyes that were incorporated into the film during manufacturing. However, fixer ("hypo") eliminators containing oxidizing agents, such as peroxide, are not permitted. Oxidizing agents not only interfere with image stability testing, but they can also promote image deterioration.

9.1.1.4.2 Photo-flo™ or equivalent rinse

Water spots, which are caused by excessive quantities of dissolved minerals in the rinse water, a marginally effective water-removal device, or both, can be minimized by using a wetting agent such as Photo-flo™ or its equivalent in the final submerged water rinse tank. Water beading into droplets on the film, which concentrates the minerals, is prevented by the addition of the wetting agent. Long-term effects of such chemical compounds on the silver image are unknown.

9.1.1.5 Dry

After being thoroughly wetted by processing solutions and rinse waters, the gelatin layer, which contains the silver image, has become swollen and saturated with water. To become useable, the majority of the water must be removed from the gelatin. The film passes through a heated chamber, and the excess water is evaporated.

9.1.2 Temperature control

One of the two main variables that affect the density of microfilm during processing is the temperature of the developer solution. If the developer becomes warmer than the desired set point, microfilm images will be more dense. Likewise, if the developer is too cool, images will be less dense. Precision processing requires that temperatures be maintained within ±1/4 ºF.

Developer temperatures should be kept as low as possible to retard oxidation and increase chemical stability. Common operating temperatures range from 75º to 100 ºF (23º to 38 ºC). Some tabletop processors, however, can require temperatures as high as 110 ºF (43 ºC) due to short dwell times and the desire for maximum processing speed. Developers for such processors need to be specially formulated to tolerate these high temperatures.

If density consistency is a major goal, low developer temperatures and long dwell times should be used. As temperatures increase and dwell times decrease, precision is usually sacrificed. Therefore the location of the processor temperature sensor or probe is critical. If it is not measuring and indicating the actual temperature of the solution developing the film, it can be providing meaningless readings.

Good process control technique occasionally requires verifying chart or digital readouts with a standard mercury process thermometer.

Caution: Be careful when handling mercury thermometers. Spilled mercury obviously creates a health risk, and it is also a powerful sensitizer with vapors that can fog unprocessed microfilm.

9.1.3 Transport speed

In addition to temperature control, another major variable in processing microfilm is operating speed or transport speed. The transport speed determines the length of time that developer will act on film. Slower transport times result in longer development times and more-dense images. Likewise, faster transport speeds (that is, short development times) result in less-dense images.

Precision density control requires constant development times (that is, processor speed). Processor speed can be monitored by measuring the rotational speed of a drive shaft or by counting revolutions of a particular roller of known circumference over which the film passes. If the processor is capable of providing variable speeds and does not have a speed indicator, a consistent technique for determining the precise speed is recommended. As part of a process control program, actual film footage passing by a reference spot should be measured for a period of 1 min. Such measuring devices are quite simple, usually having a roller with a circumference of 12 in (300 mm) and a counter that records the number of revolutions. Each time the roller makes 1 turn or revolution, 12 in (300 mm) or 1 ft of film has passed. Counting the number of feet of film that passes in 1 min provides an accurate measure of processor speed.

Caution: Even though footage counters have a rubber covering on the roller, be careful to not scratch the film while holding the roller to the film.

Some tabletop processors are designed to operate at a fixed speed and require no operator intervention to set, measure, or monitor the speed.

9.1.4 Solution agitation

With deep tank processors, it is important that the developer be thoroughly recirculated or agitated. Good agitation provides a uniform, homogenous solution temperature throughout the tank. This turbulence also washes away developer by-products (bromides), which naturally build up on the surface of film as it is being developed. Bromides retard development and can cause streaking.

Although the action of rollers turning and film passing through the developer provides some agitation, additional agitation from an adequately sized auxiliary pump might be required to maintain good control over solution temperature.

9.1.5 Replenishment levels

The development process slowly but continually consumes the developer chemicals that are responsible for converting the exposed silver halide to metallic silver. Likewise fixer chemicals that dissolve the unexposed, undeveloped silver halide are slowly but continually consumed.

If developer and fixer solutions are not diluted, rejuvenated, or replenished by the addition of fresh, unused processing chemicals, the solution's ability to provide consistently acceptable photographic results begins to decline. Fresh replenisher may be added in batches, but for greatest precision it should be continuously trickled into the tanks as the film is being processed. Precise flow rates are obtained by using valves designed for such purposes. See 9.2.4.1 for more information about continuous replenishment.

If the replenishment system is manually turned on and off, then not only should the replenisher control valves be set at the correct level, but also they should not be left open when film is not being processed. Leaving them open results in the solutions becoming stronger and more chemically active than desirable. Likewise failure to initiate replenishment when film enters the developer can result in solutions becoming weaker and less able to accomplish their intended photographic purposes.

9.1.6 Solution carryover

As film travels from one processing step or tank to another, it is desirable to prevent respective solutions from being carried into the next tank. For example, if excessive amounts of developer are carried into the wash tank, the development action might not be arrested abruptly and consistently. Environmental concerns with excessive developer being released with rinse water overflow can also be an issue. If excessive amounts of water from the developer rinse are carried into the fixer tank, dilution can become a problem. If excessive amounts of silver-laden fixer are carried into the water rinse tanks, the film can be more difficult to wash. Higher levels of silver in rinse water can be another environmental concern.

The most effective method of preventing excessive carryover is installing rubber wipers on the processor at appropriate locations. The squeegeeing action of these wipers removes the surface liquids. If the wipers are frequently checked, cleaned, and adjusted, the possibility of scratching will be minimized.

9.1.7 Safelights

Darkroom safelight fixtures should be fitted with appropriate, uncracked, unfaded filters and incandescent lamps of correct wattage and should be positioned far enough from unprotected film to prevent fogging. Safelight testing should be conducted annually or when changes have been made to fixture position, lamp wattage, filter type, film type, or exposure time. See 6.1.10.1 for more information about safelight testing.

9.2 Processor chemistry

Traditional wet processing of silver halide film requires the use of liquid chemicals and water. Most of today's processor chemistry is supplied either "ready to use" or as liquid concentrate. With concentrates, one must simply add water, stir, and use. The quality, consistency, reliability, and ease of use of these modern products have improved significantly over the years.

To fully realize the benefits of these products, it is necessary to mix, store, and use them properly. See 9.2.2 for more information about chemical mixing.

9.2.1 Water quality

Water is used in large quantities throughout the processing laboratory. In addition to being used to prepare developer and fixer solutions, water is used to rinse film at various points during the processing cycle. Water quality, which is often overlooked, plays an important part in determining certain photographic and physical results. Factors determining water quality include the following:

- pH (acidity/alkalinity);
- hardness;
- iron content;
- chlorine content;
- fluoride content;
- dissolved copper content;
- undissolved solid material such as sand and silt or flakes of iron;
- dissolved solid material;
- dissolved gasses;
- color;
- temperature.

Separately or in combination, these factors can have unpredictable negative impact on microfilm processing.

For example: Excessively hard water can result in calcium and magnesium compounds eventually coating processor parts and clogging spray nozzles, water lines, and drain lines.

NOTE – Totally softened water (zero hardness) should not be used for washing microfilm because it can cause the gelatin layer to swell and soften. Soft gelatin is more susceptible to scratching. High levels of dissolved copper from plumbing can contribute to chemical fogging in the developer. Sand and silt can clog spray rinse nozzles. Dirty water can cause scratches and abrasions. High levels of dissolved and undissolved solids can present themselves as water spots. Dissolved gasses, which contribute to low pH levels, can cause plumbing to corrode. In northern climates, municipal water temperatures can fall below 40 ºF (4 ºC) during the winter months, shrinking the film's gelatin layer, which makes film washing more difficult.

Filters designed to remove particle sizes to 0.5 micron (µm) should be installed on water lines feeding the chemical mixing area and the wash sections of the processor. Ideally, water used to mix developer and fixer should be deionized. Deionized water contains extremely low levels of impurities. It is relatively simple to generate deionized water by using deionizing tanks or columns. They are readily available from companies specializing in water treatment and conditioning. These deionizing columns can be returned for regeneration when they become saturated with minerals and the like.

9.2.2 Chemical mixing

Developers and fixers are both adversely affected by oxygen. They should be mixed with gentle agitation for minimum required times and with little or no aeration. Precision processing requires that consecutive batches of developer chemicals be mixed in an identical manner ensuring precise dilution rates and minimal oxidation.

Some mixer devices, especially those with outboard mounted propellers, can create a deep vortex, which introduces large quantities of air into the mixture. Likewise, if a pump is allowed to run dry, or if there is a leak on the suction side of the pump, tremendous quantities of air will be sucked into the solution, creating oxidation problems.

To avoid oxidation when mixing developers, always add the concentrate to the water. Because high temperatures are harmful to developer solutions, always mix with room temperature water.

9.2.3 Chemical storage

Depending on quantities mixed and usage rate, developer and fixer replenisher solutions can sit in storage for days, weeks, or months. For short periods (that is, up to a week), no special provisions need be made for protecting developer replenisher from surface oxidation and evaporation. If, on the other hand, the storage period is from weeks to months, storage containers should be equipped with a floating lid that rises and falls with changes in the solution level. These tight fitting lids help minimize oxidation and loss due to evaporation.

9.2.4 Developer replenishment

Precision processing requires that developer contained in the processor be adequately replenished with fresh solution. Developer supplier's recommendations should be consulted to determine proper levels. When carried out correctly, replenishment fulfills two main objectives: it dilutes the normal buildup of dyes and chemical by-products, and it replaces spent chemical compounds, which are consumed in the developing process.

When using replenisher that is significantly stronger than the developer in a processor, over-replenishing can contribute to higher image densities and clear area densities (*D*min). The density of these non-image areas may also be referred to as the "base-plus-fog" density. Developer that is under-replenished will generally produce lower image densities.

9.2.4.1 Continuous replenishment

To prevent fluctuations in chemical concentration resulting in swings of density, replenisher should be continuously added as the film passes through the processor. Liquids may be precisely introduced into the processor recirculation lines by using a special type of metering valve, sometimes referred to as a "flow-rater". Such valves are normally graduated in "cc/minute" (cubic centimeters per minute) or ercent maximum flow.

Film and chemical manufacturer's recommendations should serve as starting points for determining proper replenishment rates. Fine tuning might be necessary after gathering adequate operating experience. Variables such as film type, image polarity, density, and image size and spacing can affect developer depletion rates. Rate recommendations are normally given in number of liters or milliliters per unit of film. For all practical purposes, milliliters (ml) and cubic centimeters ("cc" or cm^3) are the same.

For example: A manufacturer might recommend a replenishment rate of 1.2 l per 1000 ft (305 m) roll of 35 mm film. If the processor operates at 70 ft (21.3 m) per min, it will take 14.3 min to process a 1000 ft roll. (The value 1000 ft per roll divided by 70 ft/min = 14.3 min per roll.) Using this figure and the recommendation of 1.2 l (1200 ml) per 1000 ft roll, the rate calculates to 84 ml/min (1200/14.3 = 84). The flow rater valve should be set at 84 ml/min while film is being processed.

9.2.4.2 Batch replenishment

An effective but less-repeatable method of replenishing is to add a certain volume of replenisher after processing a certain quantity of film. Using the example above, after processing 1000 ft of film, the operator would measure and add 1200 ml of replenisher to the developer tank.

Caution: There are two areas of caution when using this system: 1) unless there is active agitation in the tank, the freshly added replenisher remains at the top of the tank; 2) much of the replenisher can go directly out the overflow before it has a chance to thoroughly mix.

9.2.4.3 Constant liquid level replenishment

Replenishing for level involves checking the solution height in the processor tanks periodically and adding enough replenisher to keep them filled to overflowing. Because rubber squeegees and wipers are very effective at minimizing solution carryover, they cannot be used with the constant liquid level system. Due to variable rates of carryout and various run lengths between replenishment, this method might not provide precise control over chemical concentration. These variables become even more significant when working with small quantities of developer such as those encountered in tabletop processors. Such small volumes of liquids offer little chemical and thermal stability (that is, inertia) and are quickly affected by system variables.

9.2.5 Fixer replenishment

Replenishment of the fixer (especially when continuous silver recovery is used) is not as critical as developer replenishment. Four major reasons for replenishing fixer are to

— dilute by-product buildup;
— maintain pH level;
— maintain low silver concentrations;
— maintain sodium sulfite levels.

Sodium sulfite acts as an anti-oxidant to help preserve the active ingredient, thiosulfate ion.

Fixing solutions that are overly replenished generally do not cause photographic problems but do increase costs through higher usage. (Although it is possible that excessively strong fixer could dissolve extremely fine silver particles, practical testing doesn't confirm this.)

Under-replenished fixers, which are not continuously de-silvered in an electrolytic silver recovery unit, will eventually contain an excessive amount of silver in the form of "silver thiosulfate". When the concentration reaches several grams of silver per liter, it can retard the fixing (clearing) process and also result in high residual levels of unwanted non-image silver salts along with thiosulfate ion in the film.

9.2.6 Silver recovery

Strict environmental requirements and regulations enhance the benefits of silver recovery. Regardless of economic incentives, it is wise to recover as much silver as possible from the fixer because recovering silver electrolytically permits fixer to be recirculated and reused.

Other methods of recovering silver include metallic replacement, ion exchange, and chemical precipitation. When these methods of extraction are used, the fixer is usually chemically altered and no longer suitable for processing film.

9.2.6.1 Fixer

Recovering silver electrolytically from fixing baths involves passing silver-laden fixer solution between two electrically charged surfaces. The positively charged surface is usually made of graphite and is called the "anode". The opposing surface is charged negatively, made of stainless steel, and called the "cathode". The silver contained in the fixer is in ionic form and has positive electric charge. Because opposite charges attract, the positive silver ions cling to the negatively charged cathode. Metallic silver builds up on the cathode until its weight dictates that it be removed and stripped of reclaimed silver. Electrolytically recovered silver usually assays between 90% and 100 % pure.

Caution: Care must be exercised during the recovery process. It should not be a goal to reduce silver concentration to zero. If the recovery unit pulls 100 % of the silver from the fixer, the electrolytic action will begin to break down the sodium sulfite, which is contained in all fixing baths. When sodium sulfite is totally depleted and converted to sulfate compounds, the ammonium thiosulfate will be "attacked". When this occurs, it is referred to as "sulfiding". Sulfiding will be readily apparent due to the rotten egg smell (hydrogen sulfide) emitted. Silver on a cathode will change from hard, light tan to soft, dark, muddy brown. The fixer solution will become tainted with sulfide compounds and appear murky and cloudy.

A high degree of solution agitation is required in electrolytic recovery units. If the solution is not agitated as it passes the cathode, it will be stripped of silver and local sulfiding will occur. Likewise, if electrical current being applied to the recovery unit is too high for the agitation rate and for the amount of silver in the fixer, the excessive current will remove the silver at a very high rate and deplete the fixer between the charged surfaces, creating sulfiding.

Sodium sulfite aids the electroplating process. Its concentration in the fixer is generally between 10 and 15 g/l.

In addition, the pH or acidity level is critical in the plating process. If pH is over 5.5, proper plating might not occur. If the pH is below 4.5, the dyes might not be adequately removed from the film.

Sophisticated silver recovery units are equipped with sensing probes to measure concentrations of silver in the fixer and to automatically adjust the current applied to the cathode. To efficiently operate and maintain manual recovery units, the operator must know the silver concentration. This concentration can only be determined by testing the fixer.

This testing procedure involves combining unknown quantities of silver contained in a sample of fixer with a known quantity (typically an excess amount) of sodium sulfide and measuring the amount of silver sulfide that forms. Silver sulfide is a dark brown substance and can be easily measured with a simple photocell or colorimeter. See the manufacturer for further details on a suitable test method.

9.2.6.2 Wash water

Depending on the silver concentration of the fixer and the efficiency of the rubber squeegees following the fixer tank, various concentrations of silver will be carried out of the fixer tank and into the fixer wash tank. The amount of silver contained in this wash water should be monitored to avoid violation of environmental regulations.

There are several methods for removing silver from wash water: reverse osmosis, ion exchange, chemical precipitation, and metallic replacement. These methods are not economical and require a great deal of monitoring. Because removal is not cost effective, a goal should be to prevent large quantities of silver from being carried into wash water. Two ways of accomplishing this follow: maintain extremely low silver levels in the fixer (below 0.5 g/l); and maintain an extremely efficient squeegee action after the fixer.

9.2.6.3 Scrap film

Even though the quantity of silver contained in today's silver microfilm is extremely low (less than 2 g/m^2), there continues to be an interest in recovery. There are several ways to recover silver from film. Incineration burns off the base support and melts the silver of processed films into droplets of metallic silver, which must then be separated from the ash. Breaking down the gelatin layer through enzyme action is a second alternative. After separating silver from the base, it can be refined.

Given the small quantity of silver contained on such films and the environmental concerns that must be addressed, it would appear to make little economic sense to recover silver from scrap film.

Scrap, unexposed camera film may be put through a processing machine under total darkness conditions. Because the film has not been struck by light, it will not be developed as it passes through the developer, and 100 % of the silver halide will still be available and dissolved in the fixer. Once the silver halide has been dissolved in the fixer, any of the previously mentioned recovery methods may be used. The resulting clear film base may then be used as leader, discarded, or recycled.

If the film has been exposed or struck by light, the processing machine must be threaded so that the film passes through the fixer and final wash sections only. If the exposed film passes through the developer before going through the fixer, exposed portions will be converted to metallic silver. These metallic areas will contribute little if any silver to the fixer.

9.3 Quality considerations

After processing, film should be thoroughly evaluated or inspected to determine if all the processing conditions and criteria were successfully met.

9.3.1 Scratches

Gelatin, which makes up the majority of the emulsion layer of silver microfilm, swells and becomes quite soft as it passes through the various water-based solutions in the processor, making it very susceptible to scratching. There are many points on a typical processor that either come in contact with or come close to the emulsion surface. For example, on a serpentine drive processor, every other roller contacts the emulsion side of the film. On a helical drive processor, only the base side of the film comes in contact with the rollers. Between each main section of the processor, there might be a rubber squeegee or wiper that contacts both sides of the film. Sand, grit, or particles of iron can get lodged in the squeegee and cause significant scratching. The film-threading path on most deep tank processors is usually quite long and provides many opportunities for film to rub against a fixed surface.

There is ample opportunity for scratching on any processor, and the finished film should be checked frequently for such damage.

9.3.2 Tests for residual chemicals

An important quality-related characteristic of processed microfilm is whether it has been adequately washed or rinsed. In long-term storage, two chemical compounds harmful to the silver images are thiosulfate and non-image silver salts. There are analytical tests that can accurately determine amounts of both compounds left in the film. Such tests must be conducted not more than two weeks after processing. See ANSI/NAPM 9.17.

9.3.2.1 Residual thiosulfate

The most damaging chemical compound in processed film is ammonium thiosulfate from the fixing bath. Excessive quantities of residual thiosulfate will over time have a bleaching action on silver images and cause them to turn yellowish brown. LE 500 films should contain no more than 0.014 g of thiosulfate ion per m^2.

There are several analytical procedures for this chemical compound, and tests should be conducted regularly on processed films. They may be conducted in-house or by an outside independent testing laboratory. See 9.3.2.1.1 for more information about the methylene blue test method.

9.3.2.1.1 Methylene blue test method

The methylene blue test is the most sensitive, accurate, precise, and widely used method for determining residual thiosulfate in processed microfilms and should be conducted within two weeks after processing. The procedure involves leaching the residual thiosulfate ion from a clear area of the film and combining it with other chemical reagents to form methylene blue dye. Thiosulfate concentration is indicated by the intensity of the blue dye that is formed. This easily learned analytical procedure requires an investment in equipment (such as a colorimeter and glassware) and pre-mixed chemical test solutions commonly referred to as "reagents". Methylene blue testing services are also commercially available. See ANSI/NAPM IT9.17 for more information about the methylene blue test method.

9.3.2.1.2 Silver densitometric test method

A simple, more time consuming but less sensitive method for determining residual thiosulfate, as well as several other residual chemicals, is the silver densitometric test. It requires three test reagents and a precision transmission type densitometer equipped with a special filter. Using this method, half the length of a short strip of film is immersed in a silver-nitrate solution. The immersed half is then immersed in a sodium chloride solution followed by a thiosulfate/sulfite fixer solution. After washing and drying, the density of the treated half is compared with the untreated portion. A difference in density between the two halves indicates the presence of residual thiosulfate. See ANSI/NAPM IT9.17 for more information about the silver densitometric test method.

9.3.2.2 Residual silver compounds

9.3.2.2.1 General

Minute quantities of non-image silver remaining in film after processing can eventually darken photolytically, through exposure to light, and decrease image contrast. High residual silver levels can result from a combination of weak fixer baths, excessive quantities of silver in the fixer, and poor washing.

9.3.2.2.2 Silver sulfide test method

An effective method of detecting residual ionic silver in processed microfilms subjects the film to a solution of sodium sulfide. Any ionic silver present will quickly react with the sodium sulfide to create silver sulfide, a brown colored compound. The intensity of the brown is measured with a specially filtered transmission densitometer. See ANSI IT9.1 for test details.

9.4 Post-processing treatments

Silver microfilm is quite vulnerable to oxidants in the atmosphere. These pollutants adversely affect silver images and do so at a rate that is somewhat proportional to storage area humidity levels. To combat the effects of these destructive compounds, processed microfilm may be either chemically treated to convert the metallic silver image into a less sensitive compound (see 9.4.1 for information about toning) or coated with an impervious resin protective layer. See 9.4.2 for information about plastic resins. Such coatings are very hard and contribute greatly to scratch resistance.

9.4.1 Toning

Toning is a chemical process in which part or all of the metallic silver grains are converted to less-sensitive compounds. Toning is performed only after the film is completely developed and fixed. Toning may be incorporated in the processor at the end of the normal cycle or offline at a later time. If film is to be toned, refer to ANSI IT9.15 for information regarding accepted procedures for testing film samples to ensure that toning has been performed to the recommended degree (that is, the correct amount of silver has been converted into silver sulfide). See AIIM Special Interest Package #34.

9.4.1.1 Sulfur

A tremendous amount of experimentation has determined that partially converting the metallic silver image to silver sulfide offers outstanding protection against strong oxidants in the atmosphere. See AIIM Special Interest Package #34, and ANSI/NAPM IT9.15.

9.4.1.2 Gold

A similar level of protection is attained by toning the silver grains with gold chloride. Although costly, the protection from atmospheric pollutants is outstanding. See AIIM Special Interest Package #34.

9.4.2 Plastic resin

Although the long-term chemical effects on silver microfilm are unknown, scratch resistance and some degree of protection against environmental pollutants or oxidants may be attained with plastic resin (such as 3M Photogard™ or the equivalent). It is coated onto the film as a liquid and subsequently cured and hardened with ultraviolet radiation. The coating may be applied to either or both sides of film and is thin enough to have a minimal effect on resolution transfer when contact duplicated. Such coatings are not approved for use on LE 500 films.

9.5 Process control

The photographic processing machine is the heart of any micrographic facility. Because it can develop films from a multitude of cameras and printers, it must be reliable and repeatable. "Process control" is the science of statistically monitoring and controlling important variables of a production process. When statistics are applied to the data, much can be determined about the system's consistency. The most effective tool for monitoring a processing machine is the processor control strip. See 9.5.1 for more information about processor control strips.

9.5.1 Processor control strips

The goal of processing is to consistently convert camera or printer exposures to useable images within an acceptable range of densities. To best determine consistency of the developing action, control strips should be processed regularly (that is, daily). Control strips are short lengths of film that have been exposed in a sensitometer, a precision exposing instrument. To be meaningful, the type of film used to create the control strips should be the same as film normally processed on the processor.

Processor control strips may be purchased from film manufacturers or produced in a laboratory using a high-quality sensitometer. After processing, the precise exposures that are made on these strips result in a series of density steps. One or several density levels may be monitored and plotted. Normally two locations on each strip are monitored. One area to be measured is the clear, unexposed area (referred to as "base plus fog" or "*D*min"). Camera films should have *D*min densities below 0.10. The other area to be read is the exposure step, which results in a density near 1.20. The consistency of these density readings is an excellent indicator of the stability of the processing machine.

In practice, 20 to 25 strips are processed and measured before calculating a meaningful mathematical average. The average of these measurements becomes the "reference density" for that particular roll of raw film stock.

For maximum processing precision, when switching to a new roll of raw film stock from which processing control strips are made or to a new roll of pre-made processing control strips, a crossover test should be conducted. When nearing the end of a roll, strips from old and new rolls are processed together to determine what, if any, differences exist between rolls. To be meaningful, old and new strips should be processed together at three separate times. The average difference between the reference densities should be added to the old reference density to establish a new reference density. For example, if the current reference density value is 1.17, and if during the first crossover test, the old strip has a density of 1.10 and the new strip has a density of 1.07, then the first crossover density difference is -0.03. During the second crossover test, if the old strip has a density of 1.19, and if the new strip has a density of 1.14, then the crossover density difference is -0.05. During the third crossover test, if the old strip has a density of 1.16, and if the new strip has a density of 1.09, then the crossover difference is -0.07. The average crossover density difference is calculated as follows:

Crossover #1	-0.03
Crossover #2	-0.05
Crossover #3	-0.07
Total	-0.15
Total/3 =	-0.05

= (Average Crossover Density Difference)

The average crossover density difference is added to the old reference density to establish the new reference density.

Old reference density =	1.17
Average crossover density difference =	-0.05
New reference density =	1.12

The new reference density becomes the new aim point on the Processor Control Chart. See Kodak Pamphlet D-17.

9.5.2 Processor control chart

For processor control strips to be meaningful, the density results must be plotted on a statistically derived control chart. When creating or establishing a control chart for a particular processor, the first goal should be to learn as much as possible about the inherent level of variability by allowing the processor to operate randomly for a week or two. During this period, no corrections should be made to the processor. If resultant levels are acceptable, then no changes or improvements need to be made to the equipment. If, on the other hand, the plotting exercise shows an intolerable amount of variability, some or all of the processor controls might need adjusting or replacement. Such improvements may include a more precise temperature controller, more consistent speed controller, higher capacity pumps for better agitation, automatic sensors to open and close valves, or more finely graduated flow rater valves for better control over replenishment. See 8.5.2 for more information about control charts and figure 21 for an example of a processor control chart.

10 Inspecting the film

The sole purpose of microfilming is to generate faithful, usable, and in some cases virtually permanent reproductions of original documents. It is wise therefore to determine if the microfilm images are capable of fulfilling their intended purposes while the source documents are still available for refilming. Some level of inspection is necessary to determine if the various project requirements have been met.

The amount of labor involved in inspecting microfilm masters and subsequent generations depends, in part, on the degree of effort given document preparation and the reliability of the camera operator and equipment. It is economically prudent to allocate a portion of the inspection for trouble shooting, problem solving, and defect prevention. As the reliability of a microfilm system is improved through operator training, monitoring, testing, equipment upgrading, and tighter process control, the amount of inspection can be in many instances significantly reduced, especially in continuing projects involving similar source materials.

Regardless of the level of evaluation performed, it should be performed in a logical, structured manner with specific limits and criteria that are established and agreed on prior to the beginning of the inspection process. Despite the best of intentions, evaluating microimages can be a very subjective, frustrating experience, and it is further complicated if objective quality criteria and specifications are permitted to change or drift.

10.1 Inspection technique

It is prudent to check microfilm as quickly as possible after processing for gross defects that might have been caused by a major camera or processor malfunction. A quick inspection can identify imperfections that can be noted and corrected before large quantities of defective film are produced.

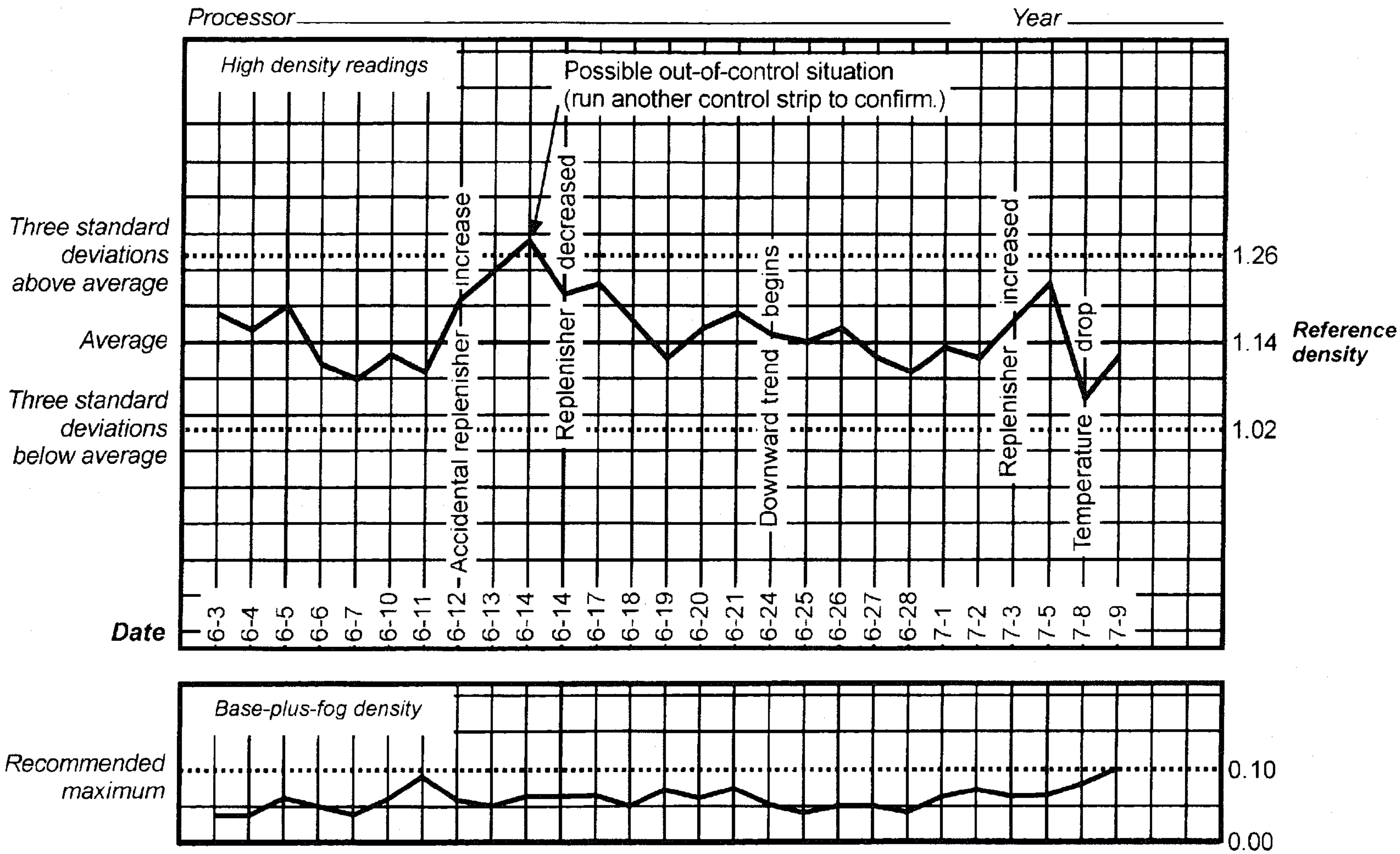
After a cursory inspection for gross defects, film should be given a more thorough inspection using any of the five techniques listed in table 6. Each level of inspection requires progressively more time, effort, and equipment but provides a greater degree of assurance that the microfilm product meets pre-established photographic, physical, chemical, practical, and bibliographical requirements. Microfilm records considered to be of permanent value should be inspected at Level 5.

10.2 Defects

See table 7. As defects are identified and their causes are determined, compile a corrective action guide book. In this guide, include actual defective samples with written information about possible causes and corrective actions; this makes an invaluable training aid for new inspectors. Types of defects include photographic, physical, and editorial defects.

10.2.1 Photographic defects

Photographic defects refer to problems associated with basic image-creating processes: exposing and processing.



NOTE — High density is monitored patch on processor control strip; base-plus-fog density is density of clear, unexposed area. This graph is only an example; users must establish their own reference density and limits.

Figure 21 — Example of a processor control chart

10.2.1.1 Density too high

The density of a camera master is too high if fine, thin lines begin to gain density. Ideally, density of the thinnest lines contained in images on a film should be no higher than the film's *D*min. For all practical purposes, the width and darkness of the thinnest lines of a given microfilm image determine the maximum density level. Because the equipment required to measure the density of lines is quite sophisticated and costly, measuring background density is an acceptable alternative. From experience, it is known that exceeding a background density of 1.30 on reasonably high-quality documents causes thin, light lines to begin gaining density, making reproduction in subsequent generations difficult. To prevent this, a density range of 1.00 to 1.20 is recommended for "average-quality" documents. As contrast of documents diminishes, maximum acceptable density can decline to a low of 0.75.

10.2.1.2 Density too low

The density of a camera master is too low if there is not enough background density surrounding the clear characters to provide adequate contrast for viewing, making duplicate film, or making paper copies. For an average document, these problems can occur at a density lower than 0.75.

10.2.1.3 Irregular areas of low density

Irregular areas of low density in image areas can be caused by shadows of moveable or fixed objects that interfere with the camera light's ability to correctly illuminate documents.

10.2.1.4 Fog marks

Unwanted areas of density can occur in random locations for a variety of reasons. The marks — which vary in density, shape, and location — may be considered only a cosmetic defect if they do not increase or add density to any characters or text. Four types of fog are chemical, light, static, and mechanical fog.

10.2.1.4.1 Chemical fog

Chemical fog can be caused by developer that is heavily oxidized, chemically depleted, or both. Chemical fog is more likely to be caused by developer that has been too strongly mixed, that has been over-replenished, that is too hot, or that is contaminated with fixer or other chemicals.

Attempting to compensate for underexposed images by overdeveloping can also cause chemical fog. The fog's appearance will be quite uniform and can add significant density to *D*min levels.

10.2.1.4.2 Light fog

Actinic light is the color of light to which film is most sensitive. Fog can be caused by inadvertent exposure to actinic light or by overexposure to what might be considered "safelight". Pattern, shape, and distance between fog marks can be a clue to the cause and subsequent preventative action.

Sources of light fog can be excessive room illumination when loading or unloading film from a camera, defective camera shutter mechanism, light leaks in the camera or processing room, the opening of camera doors inadvertently, and inappropriate or incorrect use of a safelight in the darkroom.

Edge fog normally occurs while film is wound on a spool. Light shines between the film edges and spool flanges. Although spools are manufactured to exacting tolerances, handling spooled, unprocessed film under high levels of ambient lighting can cause edge fog.

10.2.1.4.3 Static fog

Because they are electrically non-conductive, microfilms are capable of building up charges of static electricity. When these charges are released, a spark or arc is created. These bluish/white sparks are rich in ultraviolet radiation. Most films are quite sensitive and easily exposed by this light. Static fog marks will normally but not always resemble tree branches or tree roots. Polarity and intensity of the electrical charges determine the exact shapes and patterns.

To prevent arcing, most camera and duplicating films are treated with anti-static coatings, allowing the electrical charges to diffuse before accumulating to excessive levels. Maintaining adequate amounts of moisture in film-handling areas also helps diffuse electrical charges before they become problematic. A combination of anti-static coating and 50 % relative humidity levels diminishes fog problems dramatically.

10.2.1.4.4 Mechanical fog

Silver halide grains are sensitive to mechanical pressure and can be "exposed" and made developable by subjecting them to various forms of physical stress. The most common form of mechanical fog is the "half moon" or crescent, which occurs when film is buckled. Another common form of mechanical fog occurs when the emulsion side of film is scratched with a great deal of pressure prior to development. When this occurs, the scratch contains dark, developed silver.

10.2.1.5 Bromide streaks

When film is slowly processed in developer solutions that are not adequately agitated, streaks of low density can form on trailing high-density images. As exposed silver halide is developed, forming metallic silver, the chemical reaction releases various by-products, one of which is bromide. Bromide compounds from one image slowly stream over the emulsion layer of subsequent images, which tends to retard or slow the development process. This retardation creates streaks of lower density.

10.2.1.6 Milky or cloudy appearance

Milky or cloudy film is normally indicative of incomplete fixing. After development of exposed silver halide grains to metallic silver, unexposed grains must be dissolved by the fixer. If these unconverted silver halide grains remain undissolved as they pass through the fixer, the film will have a milky appearance in the range from slight to extreme.

If this problem is detected within certain time parameters, and if the cause for poor fixing is corrected, the film can be run through the fixing bath and final rinse again to remove the unconverted silver halide.

Caution: Passing the cloudy film (which now contains exposed silver halide) through the developer can result in a very high *D*min or clear area density. In this case, either bypass the developer section of the processor or remove the developer solution.

10.2.1.7 Excessive residual thiosulfate

The purpose of a final rinse or wash in the processor is to reduce the remaining thiosulfate ions in the film to acceptable levels (0.014 g/m^2 for LE 500 microfilms). The actual amount can be determined through testing. See 9.3.2.1.1 for more information about methylene blue test method.

Possible causes of excessive residual thiosulfate include the following:

- — inadequate fixing;
- — inadequate washing with water;
- — washing with extremely cold water;
- — excessively strong fixing solution;
- — excessively high concentrations of silver in the fixer, which cause inadequate fixing.

10.2.1.8 Pinkish-blue cast

Dyes chosen for most camera films are chosen to "wash out" through several stages. Some will wash out in the alkaline developer while others will disappear as they pass through the acidic fixer. At times, depending on the pH levels of processing solutions and the temperatures and duration of washing steps, a pinkish-blue cast might appear in the film. Normally the amount of residual dye is quite small and creates only aesthetic problems. If large quantities of dye remain behind, *D*min levels can be raised, affecting subsequent duplication steps. A processing goal should be totally colorless film because it contributes to more precise duplicating.

Table 6 — Levels of inspection

Level 1 Inspection
Scan over light-box
Examine 5 to 10 frames with eye loupe
Defects That Can Be Detected With Level 1 Inspection
Legibility and Estimate of Focus on Selected Frames
Estimate of Density
Image Contrast
Incorrect Exposure Levels
Reel Identification
Image Format
Shadows
Reflections
Text Lost in Gutter
Alignment
Spacing
Water Spots
Mechanical Damage
Residual Dye
Static Marks
Fog
Camera Light Balance
Uneven Development
Exposure Fluctuations
Level 2 Inspection
Scan over light-box
Examine 5 to 10 frames with eye loupe
Measure density of 3 to 5 frames
Defects That Can Be Detected With Level 2 Inspection
All of the above plus Density
Level 3 Inspection
Scan over light-box
Measure density of 3 to 5 frames
Inspect random frames on a reader for technical characteristics
Evaluate beginning resolution target
Defects That Can Be Detected With Level 3 Inspection
All of the above plus readability and focus on selected frames, resolution at beginning
Level 4 Inspection
Scan over light-box
Measure density of 3 to 5 frames
Evaluate beginning and ending resolution targets
Inspect all frames on a reader for technical characteristics
Defects That Can Be Detected With Level 4 Inspection
All of the above plus resolution at end, technical evaluation of all frames
Level 5 Inspection
Scan over light-box
Measure density of 3 to 5 frames
Evaluate all resolution test targets
Inspect all frames on a reader for technical and bibliographical characteristics and continuity
Defects That Can Be Detected With Level 5 Inspection
All of the above plus resolution at points of reduction ratio change, bibliographic evaluation of all frames

Table 7 — Defects classification and source guide

	Major	Minor[1)]	Possible sources[2)]
Blank film, clear	X		F,C,P
Blank film, black	X		F,C,P
Blurred images	X		C,O
Bromide streaks		X	P
Contraction	X		C
Density to high/too low		X	C,P
Density uneven		X	C
Double exposure	X		O
Fingerprints		X	O
Fog, chemical		X	P
Fog, edge		X	O
Fog, safelight		X	O
Fog, accidental exposure		X	O
Folded document	X		O
Foreign material of film		X	P
Frilling (peeling emulsion layer)	X		F,P
Illegible text	X		S,O
Jam	X		C
Milky appearance	X		P
Mottled density		X	P
Out of focus	X		C,O
Overlap	X		C
Pressure marks		X	C,P
Raw film stock defects		X	F
Residual anti-halation dye		X	P
Reticulation		X	P
Scratches (all types)		X	P
Static marks		X	C,P,O
Streaks		X	P
Stretch	X		C
Synchronization, out of	X		C
Thiosulfate, excessive	X		P
Washboard, high/low density cycling		X	C
Water spots		X	P

NOTES

1 Major defects negatively impact life expectancy and may either cause loss of data 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) May be major depending upon severity and the impact on usability and life expectancy.

2) S = Source document
F = Raw microfilm
C = Camera
P = Processing machine
O = Operators

10.2.1.9 Reflections in image

Images of reflected light generally emerge as high-density areas on film and can appear inside or outside imaged areas. Light is commonly reflected to film from curved surfaces of bound books printed on shiny paper, irregular surfaces (such as wrinkled shiny paper), and operator jewelry or clothing. Fog marks created by reflections can increase density of the text enough to restrict light, creating inadequate contrast on subsequent generations.

Changing the angle of camera lights can alleviate reflections from curved portions of book gutters.

10.2.1.10 Shadows in image

See 8.4.12 for more information about shadows in image.

10.2.2 Physical defects

Physical defects in the film can interfere with duplication, shorten LE, or both. Most defects can be easily detected by slowly scanning film over a properly positioned light-box.

10.2.2.1 Scratches

Scratches are the most common type of physical defect. Scratches to the film surface facing the inspector can be easily detected when illuminated from an overhead specular light source. Scratches to the surface below can be easily detected when illuminated from underneath while viewing towards a matte black surface or towards black cloth or paper. See figure 17.

When locating and correcting the cause of scratches, it is helpful to determine whether the emulsion or base side is being affected. A 100X or 200X magnification high-quality microscope is invaluable for such determinations. The microscope is focused on an image containing a scratch. If the scratch and image are both in focus at the same time, the scratch is on the emulsion side. If the scratch is in focus and the image is out of focus, the scratch is on the base side.

10.2.2.2 Gouges

Severe scratches actually penetrating the emulsion layer and removing the silver image are referred to as "gouges". When viewed through an eye loupe or microscope, gouges often appear to have rough, jagged edges. Measuring the distance between repeating gouges can offer a clue to the source if the processor or duplicator is suspect.

10.2.2.3 Rippled edges

Rippled edges can result when film attempts to travel up the sides of processor rollers. It usually indicates excessive film tension, a roller alignment problem in the processor, or both.

10.2.2.4 Nicked edges

Nicked film edges can result from processor rollers in need of replacement. Likewise, film struck on the edge by a sharp object can become nicked. If severe, nicks can create tears in the film.

10.2.2.5 Fingerprints

Fingerprints can occur on either side of film. Prints on the base side of film can normally be cleaned with a solvent and soft cloth. If, however, prints are on the emulsion side, the body oils and perspiration quickly penetrate the gelatin layer and are difficult to remove. In time, such contaminants can chemically react with the silver images and result in information loss.

Preventing fingerprints is best achieved by wearing thick, high-quality cotton gloves when handling film.

Caution: Persons handling film should be cautioned against wearing any form of hand creams.

10.2.2.6 Images slightly out of focus

Images slightly out of focus usually indicate a camera lens that needs to be refocused. To properly adjust a lens, a technician must evaluate all resolution test charts, including the center and all four corners of the test target image.

10.2.2.7 Images severely out of focus

Images can be severely blurred or out of focus for any of several reasons including the following:

- — the film is not threaded properly in the camera exposure opening;
- — the vacuum is poor;
- — if a vacuum film platen is used, the platen is not seated properly;
- — the camera vibrates;
- — the document is moving during exposure.

Film produced on a rotary or flow camera can be severely out of focus because of synchronization problems between the film and documents. Such focus loss can be referred to as blur, stretch, or smear and can appear as elongated or compressed images.

10.2.2.8 Irregular areas out of focus

Irregularly shaped portions of pages appearing out of focus can be caused by curled documents or documents moving during exposure.

10.2.2.9 Skewed images

The cause of occasionally skewed images is poor document alignment. If all images are skewed to the same degree, the camera head is not perfectly aligned with the camera bed. Proper alignment is critical for images that will be optically reformatted, scanned, or optically recognized.

10.2.2.10 Overlapped frames

Occasional frame overlapping is indicative of advance mechanism components wearing and needing replacement. With worn parts, actual images can overlap occasionally if the camera gate or mask is closed tightly to the edges of the documents.

10.2.2.11 Erratic spacing

Erratic spacing between frames can indicate worn film advance mechanisms. If this cause is identified, replacement is recommended.

10.2.2.12 Incorrect image positioning

Most camera heads rotate 360°. If a camera head is not in the proper position, resulting images will not be in the desired reading format.

If the images of a western style document are positioned on the film so that the right-hand edge of a page is adjacent to the left-hand edge of the next sequential page, the head is positioned properly. If, on the other hand, the right-hand edge of a page is adjacent to the left-hand edge of the previous page, the head should be rotated 180°.

10.2.2.13 Incorrect reduction ratio

Reduction ratio is directly related to the distance between the document and the film. If a camera head is not positioned at the proper level, the reduction ratio will not be correct.

10.2.2.14 Reticulation marks

The film emulsion layer is composed primarily of gelatin, which expands and contracts with changes in moisture content, pH, and temperature. Polyester film base is dimensionally quite stable and, for all practical purposes, does not change. If film is subjected to sudden changes, severe changes, or both, then the gelatin can crack and result in a pattern resembling a dry cracked riverbed. To prevent reticulation, refrain from wide, sudden swings in temperature, pH, and humidity.

10.2.2.15 Water spots

Processed film containing objectionable water spots can be rewashed, with various degrees of success, after adjustments have been made to the water removal device of the processor.

10.2.2.16 Algae residue

In addition to minerals left behind in the form of water spots, washing systems of some processors can be conducive to algae growth. If a washing system contains algae, small bits can be deposited on the film. Sections of the processor that experience unusually heavy algae buildup may be treated with a suitable algaecide.

10.2.3 Editorial defects

Editorial defects can be divided into two categories: missing pages or targets, and out-of-sequence images. Editorial inspection is necessary to ensure that all images have been filmed completely, that filming instructions have been followed, and that data that links the film to external files has been correctly included. The steps taken to ensure logical order or clarity of information, such as targeting and following established patterns of programming reel breaks, must be consistent with the practices of the institution or agency for which the film is being produced. Although a few defects can be detected over a light-box with the unaided eye, most can only be found in a frame-by-frame inspection while the film is magnified. When performing editorial inspection, one should have, if possible, the original documents, any special filming instructions that accompanied them, and the institution's procedures or guidelines for document preparation. For instance, images can appear to be out of focus when, in fact, the printing on the original is blurred. In such a case, having the original will save time when looking for the problem's source.

Normally, if second or third generation copies have been produced, it is desirable to use one of these and not the camera negative for frame-by-frame inspection. Regardless of the generation being inspected, the film should be carefully mounted on a newly cleaned microfilm reader (ideally, one that has been modified to not damage film being inspected). Checking for editorial or content deficiencies requires a detailed inspection. However, the inspection process is objective and decisions by qualified personnel are relatively easy to make.

10.2.3.1 Missing pages or targets

Missing pages should not be tolerated because capturing 100 % of the information is the main goal of any microfilming project. All pages, issues, volumes, illustrations, drawings, photographs, and foldouts should be present and in correct order. Any irregularities, such as missing pages, misnumbered pages, out-of-sequence pages, or pages bound upside down, should be targeted and described on the film by inclusion of appropriate targets. The inspection should ensure that all required targets are present, correctly prepared, and in the proper position on the reel. Reshoots or retakes must be done to include any and all missing items. These reshoots should be spliced into the camera master or indexed to the new location.

10.2.3.2 Out-of-sequence images

Determining the significance of out-of-sequence images and whether to rephotograph them is subjective; many factors enter into this decision.

10.3 Subjective appearance

At times the quality of microfilm images can be difficult, if not impossible, to quantify. Numerical descriptors such as density, contrast, and resolution may be used to describe microimages. However, these descriptors might not be meaningful. Quite often, images must be subjectively evaluated by eye to determine whether they meet their intended purpose.

10.4 Character formation

When evaluating microfilm images, an important attribute to monitor is the shape and formation of text characters. If the camera master is properly exposed, characters of the original document should retain their form throughout several film generations. If the characters are overexposed, they become progressively thinner on subsequent generations. Serifs, the thin portions of characters, tend to disappear as contrast levels of subsequent generations increase. Underexposed characters might tend to blossom and expand as additional generations are created. Character formation is an excellent indicator of camera master exposure quality.

10.5 Practical tests

Even though microfilm meets certain measurable criteria, it still might not be capable of delivering the end-product quality that is desired or expected. Conducting a test by occasionally running the camera master film to the final generation is recommended to determine if the finished film or paper copy meets all expectations and the photographic quality is acceptable.

10.5.1 Proofs

Because the end product of any microform system is acceptable imagery, an occasional finished proof duplicate copy should be made. It should have the same polarity, should be on the same film type, and should be the same generation as the final product. The proof should be thoroughly evaluated to determine if it meets all the system requirements.

10.5.2 Reader-printer copies

If the final microfilm generation will be used to make enlarged paper copies, making an occasional test print is recommended to determine acceptability of printed copies.

11 Retakes

When it becomes necessary to rephotograph a particular frame or group of frames, the reshot section should meet certain criteria and match the reel's original images.

11.1 Inspection

Retaken or rephotographed sections should be thoroughly inspected to be certain that the original defect has been corrected.

11.2 Matching film type

The type of film used to prepare retakes should match the original camera master if possible. Different types of film, film thicknesses, or generations should not be intermixed (for example, polyester retake should not be spliced into a reel of acetate film).

11.3 Matching reduction ratio

The reduction ratio used on the retake should match that of adjacent images.

11.4 Matching format

Image format and image position should match the original images.

11.5 Matching density

Density of the retaken images should match that of adjacent images within 0.15 and still be within recommended density guidelines.

11.6 Location

Although retaken images are usually spliced onto the main reel at either end, it might be necessary to actually replace a defective section within the reel.

12 Splicing

When joining two pieces of microfilm, splices must
- be strong;
- be capable of being flexed around small diameter rollers;
- not cause film to become brittle;
- not give off harmful chemicals;
- not be thick enough to cause focus problems during duplication;
- not have enough contrast to be construed as a sense mark by blip counters.

Film sections should be the same generation and must have emulsion surfaces facing the same direction. Be certain that images on both halves read uniformly through either the base or emulsion side. Odd numbered generation images will read correctly through the base (shiny) side of the film. Even numbered generation images will read correctly through the emulsion (dull) side of the film. See ANSI/AIIM MS18 for more information about splicing. See figure 1.

12.1 Effect of splices on duplication process

Ultrasonically spliced films are slightly overlapped for a stronger weld. Too much overlap, which is possible on manual splicers, can cause film to snag and possibly separate at the splice. The total thickness of an ultrasonic splice is nearly as thick as two pieces of film. When a splice passes through a duplicator, the high spot in the film's smooth surface acts much like a speed bump in a parking lot. This bumping action can cause a disturbing ripple effect in the drive mechanism of some high-speed printers. These mechanical ripples can show up as areas of contact loss called "slippage" or "separation" and result in out-of-focus images.

12.1.1 Clearance

In addition to the bumping action and possible slippage caused by the thickness of a splice, there is also a slight gap created between the two emulsion surfaces. This gap, or break in contact, occurs immediately adjacent to the splice and results in loss of focus. Because copies of images near a splice are normally out of focus, it is wise to maintain an ample clearance between splices and images. Though the minimum clearance should be determined by testing, 1 in to 2 in (25 mm to 50 mm) on either side of a splice should prove ample.

12.1.2 Dimensions

See ANSI/AIIM MS18 for more information about splicing.

12.2 Number of splices

If a printer or duplicator is sensitive to splices and prone to separation or slippage, then either the number of splices must be kept at zero or an adequate amount of blank film must be added to either side of the splice to avoid problems.

If printer contact is unaffected by splices, the maximum allowable number of splices can be established based on a combination of economics, aesthetics, the need to gang individual sections, difficulty encountered in producing the camera master, and difficulty in finding an appropriate spot to splice.

Currently the acceptable maximum allowable number of splices per reel on camera masters ranges from six to ten. Duplicates should contain no splices.

12.3 Legal considerations

For various legal reasons, certain microfilm files must remain uncut and splice free. For these, corrections and retakes may only be spliced on at the beginning or end of a reel and must be properly identified.

13 Document disposition

After determining that a particular file has been successfully captured on microfilm, a decision must be made concerning disposition of the source documents. Normally the agency or group responsible for the documents makes the decision about the desired disposition.

Documents should be saved until all microfilm duplication work has been completed. If during the duplication process the camera master is damaged, the source documents should be available for refilming.

The decision to save documents beyond this period is based on amount of available storage space, suitability of storage conditions, inherent value of the documents, physical condition of the documents, possibility of future needs, and possible legal ramifications.

14 Duplication

For information on duplication, see ANSI/AIIM MS43.

15 Film storage

Although it is quite often an afterthought, providing a suitable storage environment should be a key element in the design of any micrographic system. This deserves as much attention as any technical or bibliographic aspect. In harsh environments, works of technical and bibliographic perfection will deteriorate just as quickly as substandard products. See ANSI IT9.11 for more information about storage.

15.1 Life expectancy (LE) ratings

At one time, the expected life spans of various microfilm types were described in subjective terms (such as "permanent", "archival", "long term", "medium term", and "short term"). Although it was commonly understood that each term referred to a specific length of time, the terms were not well defined. In particular, the terms "permanent" and "archival" were frequently abused in advertising claims.

Recently established LE ratings describe three distinct time frames. Properly manufactured, processed and stored silver microfilms have an LE of 500 years and are referred to as being "LE 500" films. Acetate-based microfilms have an LE rating of 100 years. See ANSI IT9.1 for more information about stability and ANSI IT9.11 for more information about storage.

15.2 Temperature

Microfilm should be stored in a constant cool environment with temperatures not exceeding 70 ºF (21 ºC). See ANSI IT9.11.

15.3 Relative humidity

The relative humidity in microfilm storage areas should be maintained between 20 % and 30 % and should not fluctuate more than ±5 % in a 24 h period. All forms of microfilm deterioration increase with high humidity levels. See ANSI IT9.11.

15.4 Pollutants

A category of pollutants referred to as oxidants has been identified as the chief cause of microblemish formation on silver microfilm. It is wise to be aware of these compounds and to keep their concentration to a minimum in microfilm storage areas. This can be attained with properly designed and functioning HVAC systems. Intake air necessary for the operation of heating, ventilation, and air-conditioning systems should be filtered for both particulates and harmful gasses.

The following is a partial list of some common sources:
— ozone from office copiers;
— fresh oil-based paints;
— cleaning supplies;
— construction adhesives;
— cosmetics;
— engine exhaust fumes;
— deteriorating paper;
— poor-quality cellulose products;
— tape;
— rubber bands;
— inks;
— glues;
— textiles.

15.5 Microform enclosures

See 6.3.1 for information about microform enclosures.

15.6 Intermixing film types

A commonly asked question is "Can I intermix film types in storage?". The term "intermix" is quite subjective. It's meaning can refer to any of the following: the same building, the same room, the same air-handling system, the same shelf, the same filing cabinet, the same file drawer, the same microfiche envelope, or being in direct contact with each other. Effects of intermixing are quite varied. However, signs such as change in the color of the emulsion surface, presence of microblemishes, and bleaching and lightening of the silver image can be noted. See ANSI IT9.11.

Based on limited photographic activities testing, if the microfilm being stored is LE 500 film, then LE 100 and LE 10 films, such as vesicular and diazo films, should **not** be placed in the same filing cabinet. If, on the other hand, the storage area houses microfilms that are heavily used work copies, it is felt, based on practical experience, that all three film types may be stored in the same cabinet but not in direct contact with each other.

Again, it is important to remember that low relative humidities will retard possible harmful interactions between film types.

16 Inspection of stored film

Unfortunately, untold quantities of high-quality microfilm masters are produced, put into storage, and rarely looked at or used. When these masters are not occasionally inspected, chemical deterioration could be taking place. Therefore, it is prudent to establish an ongoing inspection procedure to determine if the microfilm is degrading in any way. See ANSI/AIIM MS45 for more information about inspection of stored film. Chemical degradation takes place when oxidants, which are common in most storage environments, react with the finely divided silver particles contained in microimages. Such reactions are accelerated at elevated humidity and temperature levels.

Before inspection begins, the purpose of the inspection should be firmly established. If the purpose is to determine which, if any, segments need to be rephotographed or copied, then a 100 % inspection must be performed. If there are no intentions of performing corrective work, the purpose might be simply to determine if storage conditions should be improved to slow any deterioration present. See ANSI/AIIM MS45.

16.1 Procedure

Although elaborate statistical sampling plans can be devised to laboriously inspect stored film, it is most effective to perform a cursory inspection on a large quantity instead of thoroughly inspecting a small quantity. The purpose is to quickly gain enough information to define potential problems and plan corrective action. Because chemical deterioration normally occurs at the beginning and end of rolls, inspecting only these portions of the rolls can make a quick determination. If the film storage method permits, the first few feet of each reel can be unwound by hand and inspected by viewing the emulsion surface using reflected light from an overhead source. If no signs are found, an occasional reel should be mounted on rewinds and completely inspected by viewing the emulsion surface throughout the entire reel.

16.2 Appearance of deteriorating film

The initial phase of the most common form of chemical deterioration is a slight, almost imperceptible changing of the neutral black silver image to a blue color. The dull emulsion surface and not the shiny base side should be inspected. As the deterioration advances, bluing will become more pronounced and eventually take on a slight metallic sheen. When this metallic sheen becomes noticeably reflective, the appearance is referred to as "mirroring" or "silvering". Such areas can be quite large and eventually become gold or bronze in color.

16.3 Microblemishes

Microblemishes take on many different forms, are caused by oxidants, and generally show up as small shiny reflective spots on the emulsion surface. By reflected light, they appear silvery. By transmitted light, as when viewing on a reader or microscope, they appear orangish/red. With adequate magnification, the spots appear to be composed of concentric rings surrounding a dark nucleus. These spots have been given many names: "measles", "redox blemishes", "red spots", "red blight", and "microspots". See AIIM Special Interest Package #34.

16.4 Vinegar syndrome

Most forms of deterioration attack only the silver image, leaving the base support unaffected. Acetate film base, however, is subject to a type of slow deterioration that occurs at elevated temperatures and humidities. In this process, the cellulose acetate breaks down, and hydrogen acetate, acetic acid, is liberated. Acetic acid, the main ingredient in vinegar, is readily detected by smell when opening filing cabinets, cans, or boxes that contain the deteriorating film base. Once this chemical reaction begins, affected films should be removed from the storage area and duplicate copies made. The acidic fumes given off by affected films act as a catalyst, initiating and accelerating the breakdown of other "healthy" microfilms in the same storage environment.

The onset of such deterioration can be significantly delayed and the process slowed by storing films in a cool, dry environment. Film stored in cool (less than 72 ºF, 21 ºC) or cold (less than 50 ºF, 10 ºC) conditions at moderate relative humidities (20 % to 50 %) can be expected to last for centuries. Film stored under poor conditions can degrade within a few decades.

Molecular sieves, aluminum silicate compounds that absorb acidic fumes liberated from deteriorating film base, may be used in airtight microfilm containers to dramatically increase the life of acetate-based microfilms. Molecular sieves are available commercially.

Strips of pH sensitive paper (A-D Strips or the equivalent) may be placed in airtight microfilm containers to monitor the progress of vinegar syndrome. They are also available commercially.

Annex A
(informative)

Micrographics standards application (sample)

The micrographics industry has standardized many practices. Applying these standards, along with supporting technical guidelines, not only assures management that a system complies with necessary legal records maintenance requirements but also facilitates data transfer, eases production maintenance, qualifies operating procedures, and controls costs.

Most standards do not stand alone. Successful systems depend on applicable standards being followed at each task level. Figure A.1 lists the more common tasks and documentation levels. Many of the applicable standards are listed in clause 2 or are cited in the text of this practice. Applications-specific standards (on such subjects as computer output microforms, public records, engineering drawings, and newspaper filming) should also be incorporated. Lists of these and other standards can be obtained from the Resource Center of the Association for Information and Image Management International.

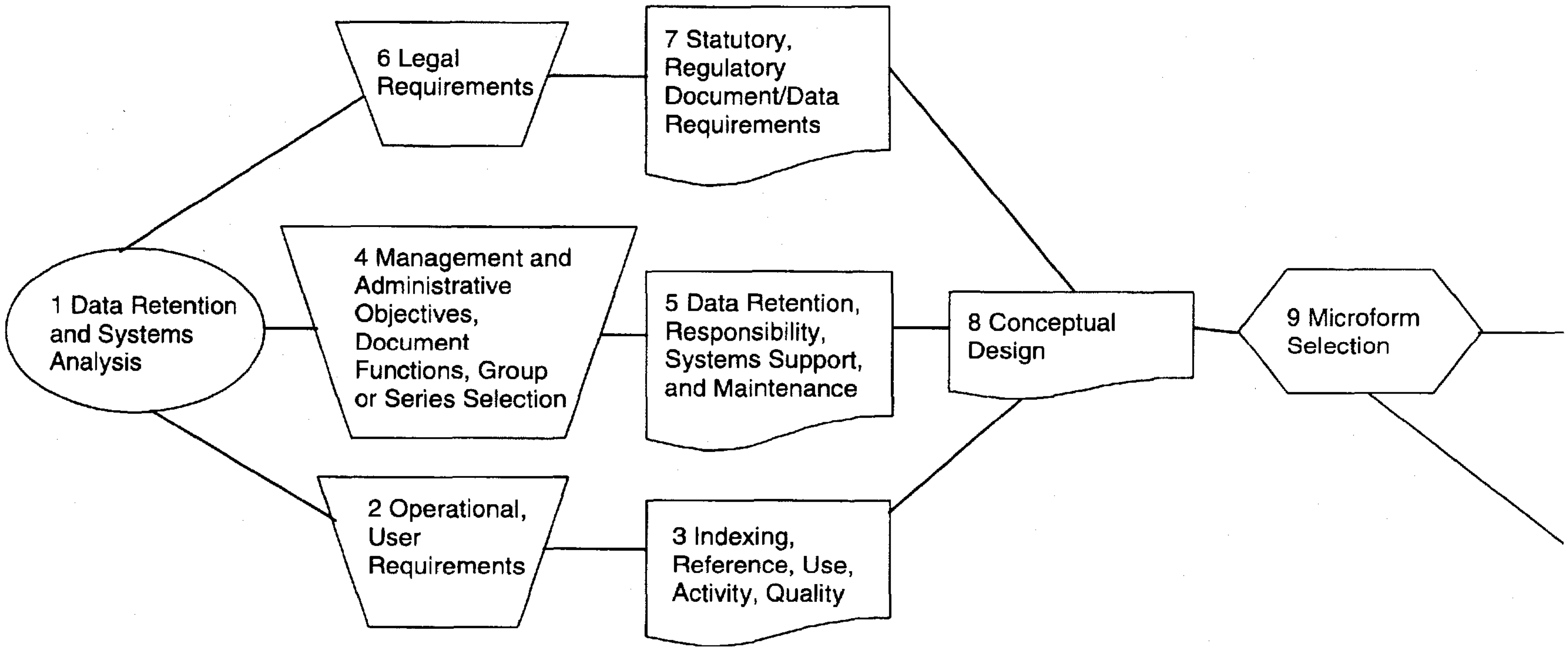


Figure A.1 — Micrographics standards application flowchart *(continued)*

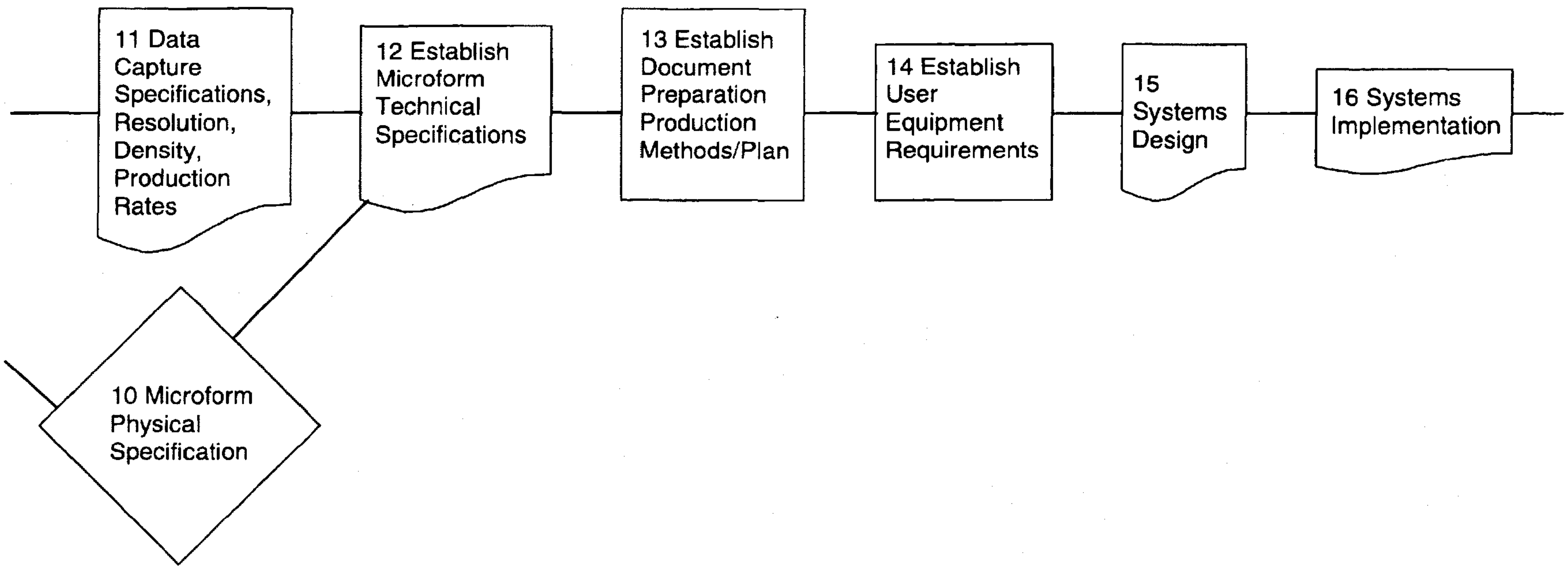


Figure A.1 — Micrographics standards application flowchart *(continued)*

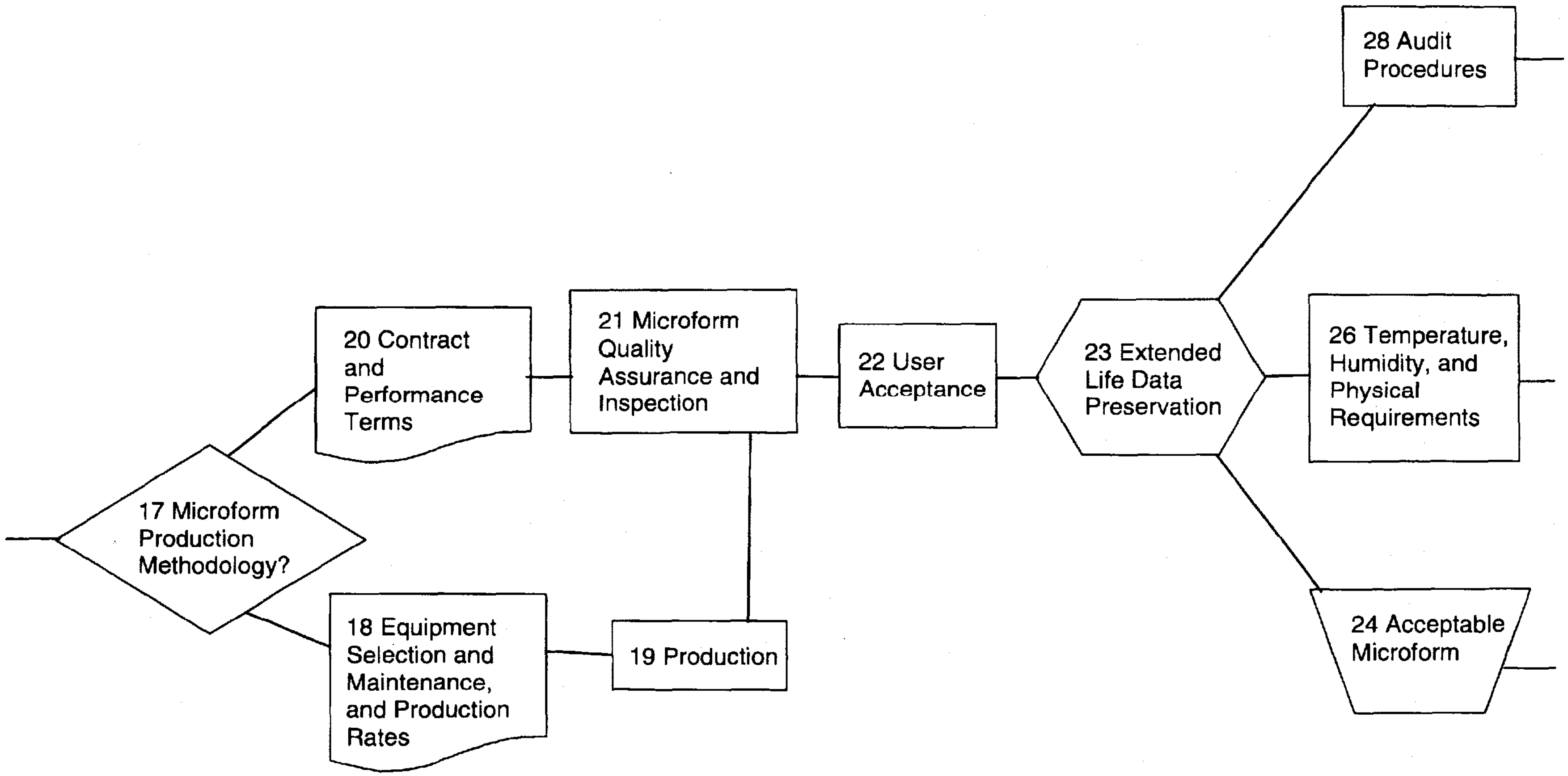


Figure A.1 — Micrographics standards application flowchart *(continued)*

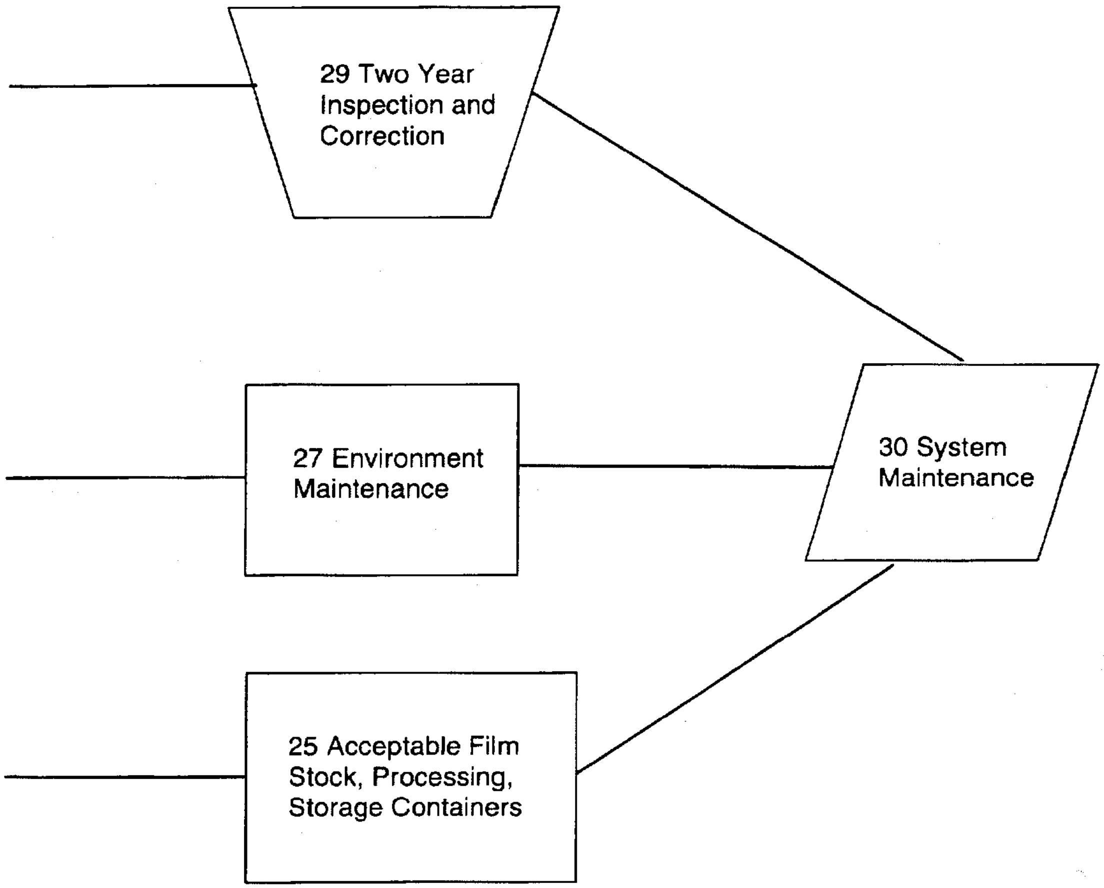


Figure A.1 — Micrographics standards application flowchart *(concluded)*

Annex B
(informative)

Blank forms

(This annex is not part of the 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 MS23-1998.)

In figures B.1 through figure B.7, this annex includes the following blank forms: information sheet, bibliographic target, microfilming report, inspection report form, format check, microfilm inspection report, and refilming log.

Figure B.1 — Information sheet

Job Operator	
Roll number	Control number
Camera	Date
Requirements	
Reduction ratio	*D*min
Height of "e" (in millimeters)	Residual thiosulfate ion
Number of generations	Index method
Quality Index	Format
Resolution pattern	Orientation
Background density	Remarks

Figure B.2 — Bibliographic target

Author(s) __________ Author's date(s) __________

____

____

____

Title __________

____

Publisher, if any __________

Publication date(s) or period covered __________

Number of volumes __________ Number of pages __________ Order __________

Place of publication __________

Edition __________ Editor or translator __________

Holder of original material __________

Editor and publisher of microfilm edition __________

Holder of master negative __________

Filmed by __________

Figure B.3 — Microfilming report

Camera number ______________________ Photographer ______________________

Date	Film number	Title of record	Volume number	Years	Exposures	Work order number

Figure B.4 — Inspection report form

Roll number ____________________ Control number ____________________

Job ____

Camera number ____________________ Operator ____________________

Date ____

Physical Defects

Defect	**Major**	**Minor**	**Comments**
Film mottle			
Fingerprints			
Frilling			
Pressure marks			
Residual dye-back			
Reticulation			
Scratches			
Water spots			
Other			

Photographic Defects

Defect	**Major**	**Minor**	**Comments**
Blank film			
Contraction			
Dark streaks			
Double exposed			
Edge fog			
Fog			
Folded documents			
Jam			
Light streaks			
Overdevelopments			
Overexposures			
Pressure marks			
Static marks			
Synchronization			
Underdevelopment			
Underexposure			
Washboard			
Other			

Figure B.5 — Format check

Item Checked	Comments
Image orientation (IA, IIA)	☐
Centering	☐
Indexing coding	☐
Image layout and sequence	☐

Test	**Requirements**	**Results**
Reduction ratio		
Resolution or Quality Index		
Background density		
*D*min		
Residual thiosulfate		
Practical test		
Other		

Comments ______________________________

Inspector ______________________ Date ______________________

Figure B.6 — Microfilm inspection report

Code: X = Reject PX = Partial reject F = Fault not in image area

Program Inspector Date of Inspection

Type: ☐Silver ☐Diazo ☐Vesicular Generation☐1 Emulsion wound out ☐2 Emulsion wound in ☐3

Defect	Roll/fiche number						
1. Summary							
2. Leader							
3. Fogged Start							
4. Targets							
a) Start							
b) Roll/fiche number							
c) Identification							
d) Date filmed							
e) Reduction ratio							
f) Certification							
g) Resolution							
h) Density							
i) End							
5. Fogged center							
6. Fogged end							
7. Density							
8. Base plus fog							
9. Resolution							
10. Process damage							
11. Splices							
12. Scratches							
13. Spacing							
14. Fingerprints							
15. Object in frame							
16. Skewing							
17. Foreign matter							
18. Contractions							
19. Centering							
20. Overlap							
21. Blips							
22.							
23.							

Figure B.7 — Refilming log

Roll number	Control number
Camera number	Date
Inspector	
Item	Location