ANSI/AIIM MS44 R1993

Recommended Practice for Quality Control of Image Scanners

Standard

Approved As

AMERICAN NATIONAL STANDARD

December R1993

ANSI/AIIM MS44-1988

AIIM

Association for Information and Image Management

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Standard for Information and Image Management —

Recommended Practice for Quality Control of Image Scanners

Association for Information and Image Management

This practice provides procedures for the ongoing control of quality within a digital document image management system. The objective of the document is to provide a means of quality control from input to output.

Foreword

(This foreword is not part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, AIIM MS44-1988.)

This document provides procedures for the ongoing verification of the quality of a digital document image storage and reproduction system.

With the coming of electronic digital imaging systems, the need for continuing the quality concepts already established in the micrographics arena has evolved. While a number of test targets are available in use for the micrographics and facsimile areas, these targets are specific to those areas and do not address the needs of the digital image management system user community. This recommended practice addresses those needs. It is proposed that the user construct his or her own target using the guidelines provided and/or obtain the scanner targets discussed in this document from AIIM.

Quality control procedures such as the ones presented in this recommended practice are necessary for every user of digital image management systems. These procedures are designed to ensure that all documents entered into the scanning system will be available for output with the necessary quality. It is recommended that these procedures be used by quality control personnel on a regular basis.

Companion documents are in the process of being developed for scanning engineering drawings larger than USA "A" size and for aperture card scanning.

Suggestions for improvement to this practice are welcome. They should be addressed to the Chairman, AIIM Standards Board, Association for Information and Image Management, 1100 Wayne Avenue, Suite 1100, Silver Spring, Maryland 20910. At the time this standard was approved, the Standards Board of the Association for Information and Image Management had the following members:

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Thomas E. Berney
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Alan S. Linden
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The AIIM Electronic Imaging Committee, C13, processed and approved this recommended practice. The following were members of the committee at the time of approval:

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American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988

1. Scope

This recommended practice provides procedures for the ongoing control of quality within a digital document image management system. The objective is to provide a means of quality control from input to output. Regular use of the recommended procedures should ensure continued maintenance of an established level of quality.

The procedures are designed for an operator and have three purposes:

(1) To allow the operator to ascertain that the scanner is properly set up before scanning actual documents;

(2) To give the operator a knowledge of what the scanner can do and, more important, what it will not do; and

(3) To provide the user with information needed to set up criteria for quality control procedures.

The targets are sufficiently detailed so that all scanners will fail at some point. The point of failure tells the user what kinds of things the scanner will not scan properly (for example, colors, type size, etc.).

Once the absolute capabilities of a scanner are determined, the user needs to know the performance of the scanner today as compared to the last time the scanner was calibrated. This practice points out the need for regular assessment of a given scanner compared to its own best performance.

This document mainly addresses scanners for 8 1/2 inch by 11 inch (USA "A" size) documents, however, the techniques may be useful for other scanner sizes as well.

In addressing scanners for digital image management systems, this document does not address the requirements of OCR scanners, color separation scanners, scanners for engineering documents larger than USA "A" size, or other special-purpose scanners.

2. References

2.1 Referenced American National Standards

ANSI C16.37-1971, IEEE Std 167-1966 (R1971), American National Standard Test Procedure for Facsimile.

2.2 Other Referenced Standards

IEEE Std 167A-1987, Institute of Electrical and Electronics Engineers Standard Facsimile Test Chart. The Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017.

2.3 Referenced Publications

AIIM TR2-1980, Technical Report for Information and Image Management—Glossary of Micrographics. Association for Information and Image Management, 1100 Wayne Avenue, Suite 1100, Silver Spring, Md. 20910.

2.4 Related American National Standards

ANSI X3.62-1987, American National Standard for Information Systems—Paper Used In Optical Character Recognition (OCR) Systems.

ANSI X3.86-1980 (R1987), American National Standard For Optical Character Recognition (OCR) Inks.

ANSI X3.99-1983, American National Standard For Information Systems—Optical Character Recognition (OCR)—Guidelines For OCR Print Quality.

ANSI X9.7-1988, American National Standard For Bank Check Background And Convenience Amount Field.

2.5 Related Publications

Bagg, Thomas C., Digitizing Documents: Guidelines for Image Quality, INFORM, 1(11): 6, November 1987.

CCITT Recommendation T-20 Standardized Test Chart for Facsimile Transmission, VII. 3, p.59.

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

3. Definitions

Definitions for most terms can be found in AIIM TR2-1980. The terms defined below are not found in that document and may be unfamiliar to the reader.

Aliasing. A group of image defects, generally caused by elements of a scanned image being smaller than and/or not registered with the picture element created by the scanner. Aliasing includes "stair-stepping" or "jaggies" which describe raggedness in curves or diagonal lines.

Halftone. The process of printing a continuous-tone picture using small black dots of varying sizes, or a picture produced by this method.

Image Scanner. For the purpose of this document, a scanner or image scanner is a device that electronically captures data from a document in a raster pattern, and that creates a digital file of the monochrome image of the document.

Linearity. A measure of actual distance versus computed distance in both the x and y axis.

Moire. An image defect caused by interference of one pattern with another, which shows as a beat frequency between the two patterns.

Point. Also printer's point. Measure of type size in graphic arts type. Nominally 1/72 inches, precisely 0.013837 inches (0.3514598 mm).

Post-test. A verification test performed after the original documents are scanned.

Pre-test. A calibration or verification test performed before the original documents are scanned.

Rectangularity. A measure of the equality of the lengths of opposite sides of a rectangle and the correctness of the angles. With perfect rectangularity, the opposite sides will be of exactly equal length and the angles will be exactly 90 degrees.

Scanner. See image scanner.

Serif. In a typeface, the short decorative cross lines at the ends of the strokes in some characters. A typeface with no serifs on any characters is referred to as a sans-serif typeface.

Stair-stepping. See aliasing

4. Principles of Quality Control

4.1 General

Quality control is the term given to the procedures and techniques that are used to maintain consistency of output. Properly used, these procedures answer the question, "Is what I am producing today as good as the best I can produce?" The answer to this question is used to determine if production can continue, or if a maintenance technician must be called.

A second question, "Is what I am producing today as good as what I produced yesterday?" may also be answered, and this answer can be used to show the variations of a piece of equipment while still within allowable performance limits.

4.2 Why Do I Need Quality Control?

In the typical digital image management system, all incoming documents are scanned, indexing information is entered, and the original paper documents are eventually destroyed. In some systems the scanned image of the document may never be examined until it is needed. Strict quality control is required to assure that the images stored are of acceptable quality and are locatable by way of the index.

If a scanner is not operating properly, a large number of useless images may be stored on the system. When the problem is discovered and corrected, the original documents will have to be scanned again. Procedures should be established so that any problems are discovered while the original documents are still available.

The quality control procedures described in this document allow the user to make sure that the system is performing today as well as it was when originally adjusted by the manufacturer. Used on a regular basis, these procedures can assure the user that the scanner will produce digital images of sufficient quality for their intended use.

4.3 Establishing a Quality Reference

It is extremely important to establish the definition of "good output" from a digital image management system. It is the nature of these systems that some images (black-and-white text) will be more faithfully recorded than others (halftones, color, etc.). Comparing a current target image against a known reference allows a nontechnical user to easily make judgments on system quality.

To establish a quality reference, the entire system must be working. The scanner should be adjusted to provide the best possible results for the type of material to be scanned. All of the targets, the three described in this practice, and all targets made by the user, should be scanned. The targets should be output to hardcopy and carefully examined. If the quality of the targets is sufficient for normal use, the hardcopies should be carefully preserved and the digital images should be permanently stored on an electronic media. All scanner adjustment settings should be noted on the hardcopy.

If the normal use of the scanner is to scan all documents in the order in which they come in, without regard for content, then the scanner setup used for the referenced should reflect the best compromise of settings for the different types of orginals that will be encountered.

Some users change the scanner settings for each document according to the content of the document. Other users sort documents according to scanner parameters, and change the scanner settings before each batch of documents of the same type (for example correspondence scanned as one batch, pink invoice copies as a separate batch) or have separate scanners for different types of documents. In any of these cases, it is desirable to create a separate quality reference set for each type of document which will be treated separately.

The user should be aware that any maintenance done to a scanner may affect the actual results of the user-controllable settings. For this reason, any time the scanner is recalibrated by a technician a test run of all targets should be made. Once a match for the original quality of the targets has been achieved, the new proper settings should be recorded. If the original quality of targets cannot be achieved, then either the scanner still has a problem, or the calibration was not performed properly. In either case, additional corrective maintenance is probably necessary. (A good general rule is to run your test targets before signing off on maintenance. It is easier to make the technician re-adjust the scanner immediately than to call the technician back when you next do a test run before a scan batch.)

4.4 Pre- and Post-testing

While it is desirable to make sure that every original document is scanned correctly, it is clearly not practical to do a test run before each document to be scanned. When batches of similar documents are to be scanned, a good compromise is to do a test run before the batch, check that the scanner is properly set up and working, scan the batch, then do a test run after the batch to make sure the results are still acceptable. If the final prescan test run and the postscan test run are the same, the scanner can be assumed to have been working properly during the whole scanning session if the scanner adjustments were not touched during the scanning session. If the postscan test image is not acceptable, the document images in the scan batch should be examined to determine which, if any, must be scanned again.

Where the scanner is adjusted separately for each original document, the pre- and post-testing approach outlined will not work. One approach for this situation is to determine, by way of pre-testing, a small number of allowable settings which the scanner operator may use during the entire scanning session (one setting per document type). This pre-testing will be done primarily with a user-created target as described in Appendix A. Following the scanning session, the operator should post-test with the same targets, using the settings established in the pre-test run. Comparing the respective pre- and post-test runs will determine if the scanner has maintained its calibration, but cannot ensure that the proper settings were used for each document within the scanning session.

4.5 Record Keeping

A record (log) of all test runs should be maintained. A test run will consist of all targets which are relevant to the type of original for which the scanner is being adjusted.

This record provides management with the assurance that quality control procedures are being followed, but more important allows a technician to spot a growing problem before it becomes too serious. (An example of this would be if the log showed that the threshold setting for a proper image was consistently changing in one direction, then a light source may be going bad.)

The log shown in Figure 1 should be completed for each test run. If multiple test runs are required to produce a satisfactory image each test run should be recorded to assist the technician. (Appendix B contains a blank log sheet, suitable for photocopying.) The number and type of settings will vary from scanner to scanner.

5. Frequency of Testing

How often test runs should be made depends on how much scanning will take place, and the consequences of improperly scanning documents.

The best security is provided by doing a test run before and after each batch of documents scanned, where a batch is a number of documents scanned with the same

Date	Initials	Settings	Results	Comments
2/5	RTG	7 50 90	OK	INVOICES
2/6	JEN	12 50 95	TOO DARK - NG	Blue Statements
2/6	JEN	8 49 92	OK	Blue Statements

Figure 1. Test Run Log

settings. This may be ten documents or ten thousand documents, however the batch should be terminated at the end of a shift, and new test runs made, even if all documents have not been scanned. If the pre- and post-test runs are acceptable, the scanned documents will generally be acceptable.

If a scanner is known to be stable, the test runs after each batch can be eliminated. In this case it may be desirable to print out and examine the last document scanned to make sure it is acceptable. Testing only at the beginning and end of each scanning shift or work day may be acceptable in some operations, but this should be the minimum testing frequency.

Frequent testing is strongly recommended because it minimizes the risk of lost time or lost documents. Lack of frequent testing carries the risk of scanning documents which will be unusable, and committing nonerasable storage to these documents. By the time a scanner problem is detected, thousands of documents may have been scanned, and will have to be scanned again. A worse risk is incurred if original documents are routinely destroyed after scanning.

6. Procedures for Test Run

Typically, a test run will include all three of the standard targets and whichever user-created targets are relevant to the type of original to be scanned. The procedures in Sections 6.1 to 6.7 should be followed.

6.1 Setup of Scanner Parameters

The scanner parameters should be set up to exactly match the original scan parameters established for the most recent quality reference for the type of originals to be scanned.

In a situation where a scanner is known (via the log) to be drifting in calibration, it may be desirable to initially adjust the scanner to the settings that worked at the end of the most recent scan of the same type. This should be a temporary situation until the scanner can be fixed. Consistently operating in this mode indicates that either there is a problem with the scanner's stability, or that the quality reference set does not reflect the proper settings.

IMPORTANT: For a test run which is a post-test of a batch of a consistent type (a test run made after the originals are scanned), DO NOT re-adjust the parameters, as the point of a post-test is to make sure that everything worked correctly as set up.

6.2 Placement of Target on the Scanner

Targets should be placed on the scanner in the same manner as the original documents will be processed. One of the tests available on the test targets allows a user to determine how well the target is aligned on the scanner. This test is defeated if, for example, originals are fed via a document feed, but the target is carefully hand-aligned.

6.3 Scanning

The targets should be scanned using the same procedures used for normal original documents. Do not change any scanner settings between targets.

Typically, electronic images resulting from test scans are placed in temporary storage while the image is being printed and evaluated and while any technical problems disclosed by the test scans are rectified. After use the electronic test images may be erased or stored to permanent memory for retention.

6.4 Examination of Targets on Screen

If the system provides the capability to view images on a screen with acceptable resolution, the test targets may be examined on a screen. For some users, this may be sufficient, and hardcopy need not be produced. It is recommended that screen examination be used where possible, until a satisfactory test run is achieved, with the final (successful) run being output to hardcopy.

The user should be aware that both screen examination and paper examination may introduce distortion. If the printer used for output of text images is not aligned, or introduces image problems (wavy lines, dark spots, light spots, etc.), these may be erroneously attributed to the scanner. A CRT may introduce distortion due to changing the aspect ratio of the image (a circle in the image appears to be oval), aliasing (thin lines disappear, blink, or appear jagged), or simply by having a resolution too low to show the detail of the image.

The main disadvantage of screen examination is that a user has no easy way to compare the current scan against the reference scan. While an experienced user should become accustomed to examination on the screen, the novice may have problems deciding if a given image is good enough to accept. Flipping back and forth between the test image and the reference image on the screen is much more difficult than placing two sheets of paper side-by-side for examination. If a system can display two pages at once, the user must decide if the screen images provide sufficient detail for evaluation.

A second major disadvantage of screen examination is that some displays do not permit display of a full page image at the full scanning resolution. Typical systems will either display a full page at reduced (sampled down) resolution, or will display a window into the page at full resolution. Neither of these alternatives is as good as looking at a printed page.

NOTE: The user should refer to the manufacturer's installation and operating instructions for the display to assure and operating instructions for the display to assure that it is set up properly.

6.5 Printing of Targets

It is recommended that the test scans be output to paper. This provides an end-to-end system check, allows a user to quickly ascertain that the output is acceptable, and provides a record which a maintenance technician can make use of when a problem is detected.

6.6 Determination of Problem Areas

If the printed output of a test run is not acceptable, the printer should be checked. This is done by calling up the digital image of the quality reference (known to be a good image) and printing it. If the output of the known good target(s) is not acceptable (is not as good as the hard-copy kept on file), then the printer is probably at fault. If the output of the reference data is acceptable, then the scanner should be checked.

NOTE: These targets were not designed to test storage media, such as optical disks, tapes, etc., or data compression/decompression functions of hardware or software. These items may be tested with standard tools, normally provided by the system vendor. Since these items are low-failure, and since failures in these systems usually produce images that are broken up rather than degraded, they should not be suspected of causing a system problem until the printer and scanner adjustments have been eliminated as possible sources of any problem(s).

6.7 Record Keeping

Each test run should be recorded on a log sheet. When a test run seems to point to an equipment problem, all settings used for the scan should be noted on the back of the printed output, and the document should be saved for the technician.

7. Target 1: IEEE

The IEEE Std 167A-1987 target (see Figure 2) was designed by the Institute of Electrical and Electronics Engineers as a facsimile machine test target. It was adopted for use by this recommended practice because of its usefulness to a technician, and because it provides a continuous-tone photograph, gray scales, precision measurement marks, resolution charts, and test characters.[1]

IMPORTANT: The usefulness of this target is in its continuous-tone nature (finding out at what level of grey the scanner decides that a point is black). A photocopy of this target, not being a continuous tone image, is completely useless for testing a scanner.

7.1 Threshold for Grey Levels

Grey scale patterns #7 and #8 are 15-step reflection density areas. Pattern 6 is a continuous density wedge. The values of the steps on the step wedges are given in the pattern description sheet which accompanies the IEEE 167A target, but are not particularly important by themselves. The primary use of these gray scales will be to show the threshold point at which the scanner decides that a given area is black rather than white. The threshold point transitioning from black to white may be different from transitioning from white to black on some scanners due to adaptive thresholding.

Once the optimum threshold adjustment for scanning a particular type of original document has been determined by testing, run the IEEE target and observe the point at which the bars turn from white to black. The continuous wedge will typically have a broken or ragged appearance at this transition area. The step wedges may transition cleanly (one step black, the next white) or one box may have a broken appearance.

In daily testing, observe if the white-to-black transition points on the daily run are in the same place as on the quality reference copy. If so, the threshold setting is properly adjusted.

7.2 Resolution

The use of the NBS 1010A bar type target resolution patterns (14a and 14b) is not recommended for scanners having a fixed aperture less than or equal in size to 600 pixels per inch.

The Prestrecov Star pattern (#12) is composed of tapered lines over 360°. At the center the lines are very narrow, and will blur at varying distances from the center. The distance of the blurring from the center is an indication of the resolution of the total system. The shape of the blurred area is a function of the direction of the scan. The size of the blurred area may be a function of the

[1]Copies of the IEEE 167A target are for sale and may be obtained from AIIM or from the Institute of Electrical and Electronic Engineers, Inc.

Figure 2. IEEE Std 167A-1987 Facsimile Test Chart (This is an example, do not use chart for testing)

Pattern Descriptions

The pattern number given in the following description may be identified from Figure 1. This chart is designed for scanning in either direction, horizontally across the page.

IEEE Std 167-1966, Test Procedure for Facsimile was based on previous issues of the IEEE Test Chart.

Patterns 1 and 2. 96 lines per inch (3.78 lines per millimeter) consisting of 48 dark and 48 light lines, substantially equal in width. In pattern 1, the black corresponds approximately to step 2 and gray to step 7 of pattern 8. In pattern 2, white represents paper white and gray to approximately step 11. These patterns are intended for generating low-modulation high-frequency signals at both ends of the density scale—useful for testing modulation characteristics at edges of band in a frequency shift system.

Patterns 3, 4, and 5. Vertical bar patterns at 10, 50, and 96 lines per inch (0.394, 1.97, and 3.78 lines per millimeter) of substantially equal width—useful for square-wave testing at several keying frequencies.

Pattern 6. A continuous density wedge designed so that at equal intervals of distance across the page, the variation in reflectance will be roughly equally perceptible to the eye.

Patterns 7 and 8. Reversed step tablets of 15 steps with reflection densities corresponding the approximately equal perceptibility modified to provide smaller low-density increments. Consistent with conventional practice, paper white is understood to be equal to 0.00 in density (approximately 0.06 on an absolute scale). For patterns 7 and 8 the relative reflection densities are shown in Tables 1 and 2, respectively.

These patterns will assist in appraising gradient and absolute scale. They are useful for checking halftone characteristics. Reversed sequences are used since the dynamic halftone characteristics may differ for a rising density or a falling density scale.

Pattern 9. National Bureau of Standards (NBS) type repeating tri-bar resolution test pattern. Twelve complete sets of three-line patterns are repeated across the sheet. Alternate groups are of different line spacing. Density values are shown in Table 3. This pattern is useful for checking definition.

Pattern 10. Rectangle with 45° diagonal marks at each corner—useful for checking index of cooperation, skew, and paper-feed error.

Patterns 11 and 17. White wedge on black background and black wedge on white background, 0.07 in (1.78 mm) to zero—useful for checking single-line definition.

Pattern 12. W. and L.E. Gurley type Pestrecov Star pattern. Outer circle 50, second circle 100, and third circle 200 lines per inch (1.97, 3.94, and 7.87 lines per millimeter).

Pattern 13. Truncated fan-type multiple-line test pattern. Calibrated in lines per inch—useful for checking multiple-line definition along scanning line, envelope delay distortion, and ringing.

Patterns 14A and 14B. NBS type Microcopy Resolution test pattern. Numerals indicate the number of cycles (one black plus one white line) per millimeter (that is, line pairs) —useful in checking high definition systems.

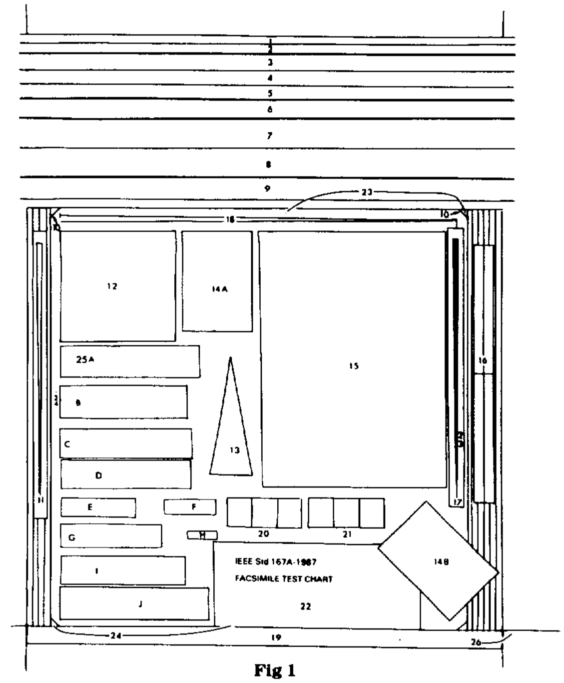

Fig 1
Pattern Arrangement

Pattern 15. Photograph with detail in highlight and shadow. The limiting densities of the photograph approximate those of test patterns 7 and 8.

Pattern 16. Vertical gray steps with relative reflection densities of approximately 0.95 and 0.27—useful in testing rising and falling transient characteristics and level variations.

Pattern 18. Horizontal "V" pattern with 0.13 in (3.3 mm) opening. Number of scanning line crossings of both lines, multiplied by 7.7 will equal number of lines per inch (multiply by 0.3 for number of lines per millimeter).

Patern 19. "Fence" pattern with 0.01 in (0.254 mm) lines 0.10 in (2.54 mm) apart—useful for checking jitter and measuring available line length.

Patterns 20 and 21. Halftone dot screens. Reproduced in approximately 10, 50, and 90 percent black, left to right and at 65 dots per inch (2.56 dots per millimeter) at a 45° angle for pattern 20, and 120 dots per inch (4.72 dots per millimeter) for pattern 21.

Pattern 22. Title and credit box. Three sizes of Times Roman type font.

Patterns 23 and 24. Fiducial dots forming a 3, 4, 5 right triangle—useful for indicating the presence of skew by comparing the hypotenuse of the two patterns.

Pattern 25. Typefaces as indicated—useful for checking readability.

Pattern 26. Extension lines to permit measurement of available line and useful length of copy.

Table 1
Pattern 7 Density Values

Step	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Density	0.01	0.03	0.11	0.21	0.34	0.47	0.60	0.74	0.88	1.02	1.15	1.30	1.46	1.63	1.78
Standard Deviation	0	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04

Table 2
Pattern 8 Density Values

Step	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Density	1.71	1.55	1.37	1.25	1.13	1.02	0.93	0.76	0.63	0.48	0.36	0.22	0.13	0.04	0.01
Standard Deviation	0.04	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0	0

Table 3
Pattern 9 Resolution Values

	Group A						Group B					
	1	2	3	4	5	6	1	2	3	4	5	6
Lines per inch	61.0	86.4	122	173	244	345	406	284	203	142	102	71.1
Lines per millimeter	2.40	3.40	4.80	6.81	9.60	13.6	16.0	11.2	7.99	5.59	4.02	2.80

NOTE: Group A has coarse lines starting at the left. Group B has coarse lines starting at the right.

Figure 3. Pattern Descriptions for IEEE Std 167A-1987 Facsimile Test Chart

threshold. The sheet accompanying the IEEE 167A (Figure 3) gives a method of approximating the resolution of the scanner by the position of the moire pattern generated by the interaction of the star and the scanner aperture.

Pattern #13 may be used in the same way as the Prestrecov Star, but in one dimension only. A moire pattern will be produced at the point approximately equal to the scanner resolution.

7.3 Linearity and Rectangularity

Testing the linearity and rectangularity of the system is typically not a daily test, but rather a test done during calibration to make sure that the system is not distorting images.

To test linearity, carefully measure the inside lines of pattern #10. The length of line on the copy should match the length of lines on the original. All lines should be straight, and lines on opposite sides should be equal.

The length of opposite sides will be equal and the distances between the diagonal corners of pattern #10 will be identical if the rectangularity of the image is perfect.

NOTE: Failure of this test is often caused by compression/decompression hardware rather than scanner hardware.

7.4 Text

Examine the small characters to determine the smallest type which is legible. This should not vary between the daily test runs and the quality reference.

The photographic nature of the IEEE target makes it different from the normal (typically printed) material scanned. The ability to read the very small (2 or 4 point) type on the target may not imply the ability of the scanner to reproduce that size type from printed copy. The text on the AIIM target, which is ink-on-paper, is a better measure of this.

7.5 Other Tests

The IEEE 167A target contains a number of test images not described in this practice. These are described on the sheet accompanying the target. Some of these tests may be useful for specific application requirements.

8. Target 2: AIIM Scanner Target

The AIIM scanner test target is an ink-on-paper target that simulates conditions that may cause scanner problems. A reduced copy of the chart appears in Figure 4. The explanations below describe the elements of the chart, and tell the user what to look for.[2]

IMPORTANT: All photocopy machines introduce image distortion of some type. Typically, photocopying the target will destroy the usefulness of the size, placement, black, and halftone test areas.

8.1 Size of Scan Area

If the scanner has an adjustable scan area, check that the scan area is the proper size.

At the corners of the target are black boxes which run off of the edges of the target. If the boxes do not run off of the edge of the scanned image, the scanner area may be too large.

NOTE: Some printers in image management systems do not print to the edge of the paper. This must be considered in evaluating the printed target.

At the corners, and at the center of each edge, a line of numbers runs off the edge of the target. If the digit "0" is not visible in all of these sequences, the image has been clipped, and the scan area is too small, or the target was not properly aligned.

NOTE: Some printers in image management systems do not print to the edge of the paper. This must be considered in evaluating the printed target.

8.2 Alignment of Page

If the scan area is the proper size, and if the target is perfectly aligned, the "0" digit will show at all corners and at the center of each edge. If the image size (or printout size) is reduced, look for the same number appearing at all points. Different numbers appearing at opposite sides of the target indicate that the target was positioned off-center or rotated.

8.3 Text

Text in a number of fonts and at a number of sizes is displayed in the text area. These represent some of the smaller sizes likely to be found in documents.

During initial evaluation of a scanner, examine the small characters and punctuation to determine where scanning problems may occur. Look for legibility of the small characters and look for detail, such as the serifs on small characters. Examine the News Gothic Bold Reverse font for character lines that may be filled with black. It is

[2]Original copies of the target are sold by AIIM.

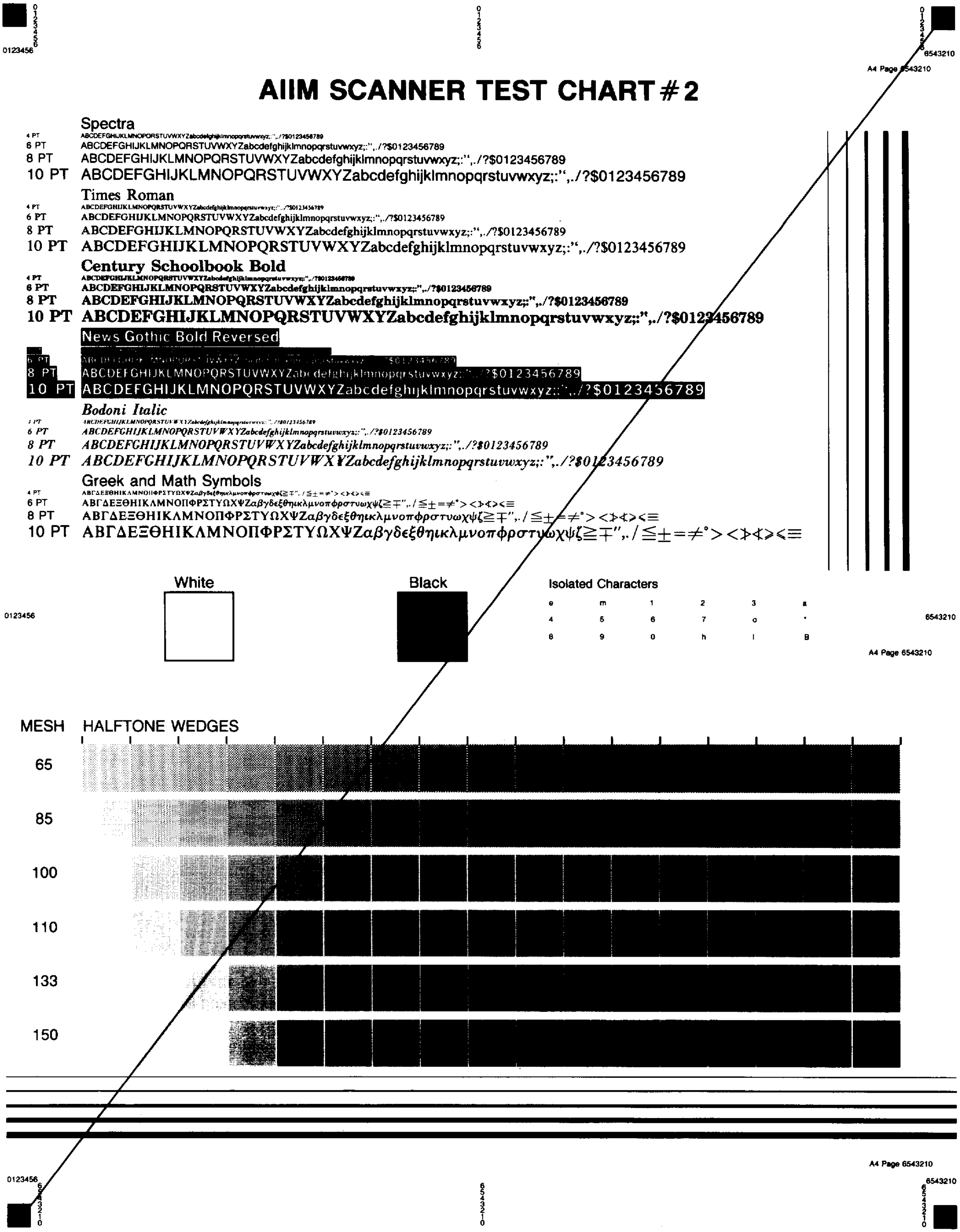

Figure 4. Reduced Copy of AIIM Scanner Target

important to know at what type size the scanner will lose the distinction between lower case letters such as a, e, c, and o. A properly adjusted scanner with a scan resolution of 300 points per inch should preserve this distinction on 4 point type.

The stated size of type is in printer's points (approximately 1/72 inches), and typically refers to the distance from the top of the tallest ascender in a typeface to the bottom of the lowest descender in the typeface. The actual height of a lower-case letter (called the x-height) varies by font, and there are variations even in the same font depending on type designer. This may result in two type samples claiming to be 6 point times roman that actually have different x-heights. Legibility of a scanned image will depend on the number of scan lines that fit within the x-height of a character, the quality of the original image, the focus of the scanner, and the capabilities of the electronic imaging system. During a normal test run, examine the smallest characters which were recognizable on the quality reference made during calibration. If the scanner is properly adjusted, those characters will still be recognizable on the current test run.

8.4 Horizontal and Vertical Lines

There should be five horizontal and five vertical lines on the page. Verify that the thinnest line is visible. Note that stair-stepping in the lines is normal if the target is not exactly parallel to the scan lines.

8.5 Diagonal Line

The diagonal line across the target is a test for uniform transport movement. The line should be smooth and straight within the capability of the scanner and recorder. Breaks in the line may indicate that a mechanical transport is not working smoothly, or is being forced to pause and restart.

8.6 Isolated Characters

The isolated characters simulate a page number or part of a mathematical equation. Because of the large white space around each character, some scanners will see these characters as dirt specks, and eliminate them. Some scanners will fail on the degree symbol (last column, center row) and display it as a solid dot.

8.7 Black-and-white Areas

The black-and-white areas allow solid areas for density checking using a densitometer. Normally, visual examination is sufficient to determine if the white area is clear and the black area is solid black. Failure to show the black area as solid black is usually a printer problem rather than a scanner problem, and the printer should be checked using the reference image.

NOTE: Densitometric values for images that are output using toning processes vary significantly from the silver halide-based systems. The user should be aware that measurement of toned images could be unique to that particular system. There is no standard for comparison of these measurements.

8.8 Halftones

Halftones pose a problem for most scanners because there are only a small number of scan lines across each halftone dot. This results in a moire pattern, which will vary according to the scan resolution, halftone mesh (dots per inch), angle of the target, and placement of the target. Currently the only known way to eliminate moire is to scan at high resolutions (more than 1,000 lines per inch).

Given that most scanners will not reproduce halftone dots perfectly, the evaluation criteria are the lightest (smallest) halftone dot that the scanner will recognize, and the darkest (largest) halftone dot area that the scanner will not see as solid black.

On initial evaluation this range should be noted, because if a halftone is scanned where most of the detail is in the very light or very dark areas, the scanner may see solid white or solid black, and lose the detail. Generally, little can be done about this, although some scanners can vary the range of capture via an adjustable threshold. For the user this means that to capture all (or most) of the information in these halftones, the scanner must be adjusted for each picture. If a very light picture and a very dark picture appear on the same page, two scans may be necessary.

The halftone mesh (halftone dots per inch measuring along a 45 degree angle) used varies from publication to publication. In general, the usage is as follows:

Newspapers	65 to 85 mesh
Technical documents, manuals	85 to 110 mesh
News magazines	110 to 133 mesh
Art magazines	150 mesh and up

During a normal test run, examine the lightest box visible and the darkest box which is not solid black for each halftone mesh. These should be the same as on the quality reference output. The threshold setting of the scanner will have a direct effect on this test.

9. Target 3: RIT Process Ink Gamut Chart

The color target discussed in this practice is the Rochester Institute of Technology process ink gamut chart[3] (see Figure 5). This chart represents the range of colors

[3]Copies of the target can be obtained from AIIM or the Rochester Institute of Technology.

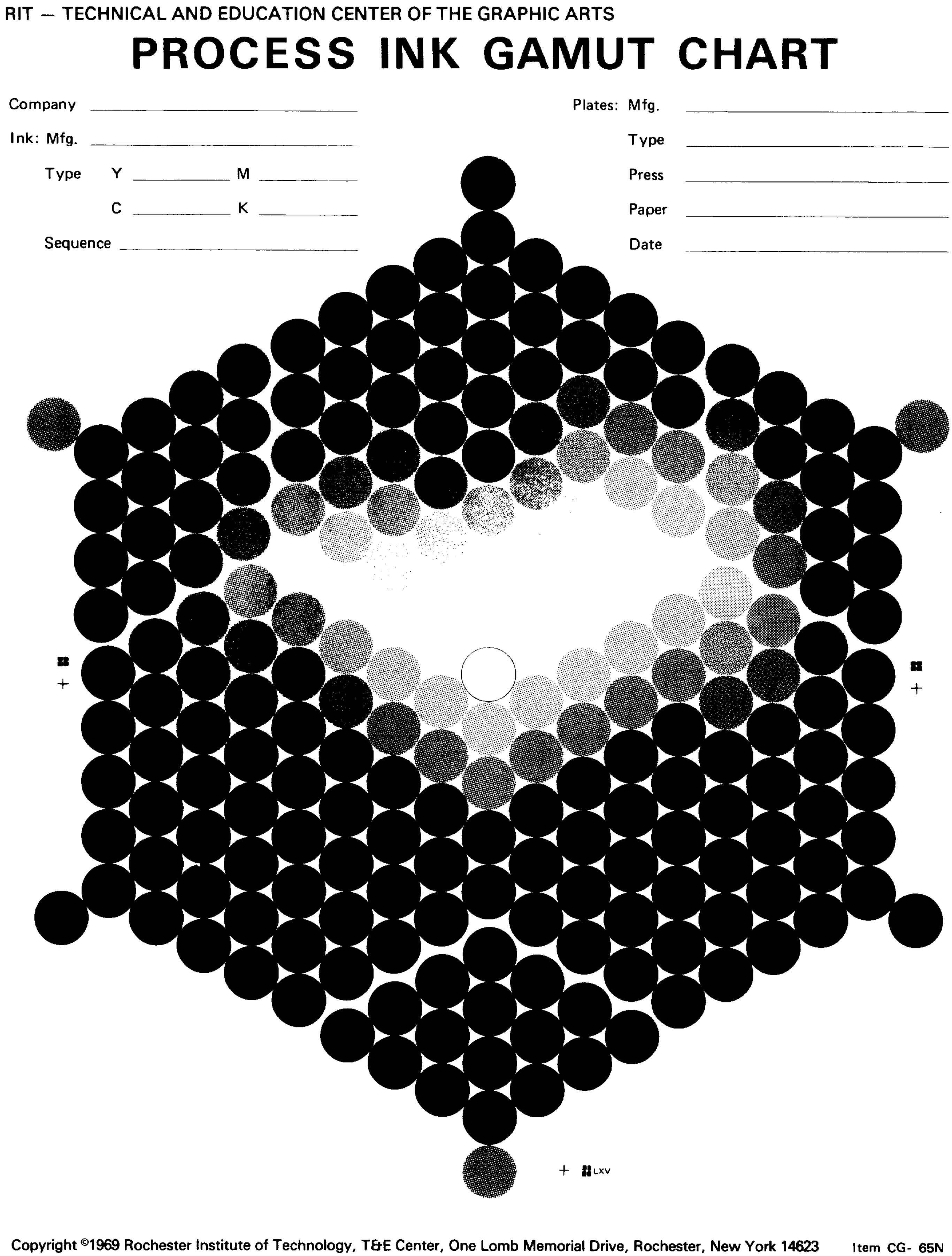

Figure 5. RIT Process Ink Gamut Chart (This is an example, do not use chart for testing)

which can be printed using standard process inks. This is the type of color printing which will be found in most magazines and newspapers.

The process ink gamut is an important test to run, even if scanning of color images is not normally done. The reason is that this target is sensitive to changes in the threshold setting of the scanner and will show slight changes easily.

9.1 Color Blindness of Scanners

Most scanners are blind in some color, typically in the color of the light source they use. A scanner using a red laser will typically not see certain shades of red ink; a scanner using a blue CRT will not see some shades of blue ink, and so on.

Most scanners will resolve each scan site (pixel) into either black or white. This means that for every spot on every scan line, the scanner will make a decision, based on how much light is reflected from that spot, whether to call that spot "black" or to call that spot "white." The scanner will see black in areas where the scanner's colored light is absorbed by the color pigment (ink, etc.) on the target, and little light is reflected. Colors matching the color of the scanner light source reflect as much light as white, and are therefore not visible to the scanner.

Scanning and printing the process ink gamut chart will produce a large number of black circles, some circles in various shades of gray, with moire patterns, and some circles not printed. The gray circles are due to the overprinting of the four basic colors used to produce all of the other colors. In general, a color on any printed material will be scanned the same way that color is scanned in the gamut chart.

9.2 Scanning Color Pictures

If color pictures are scanned on a typical (monochrome) scanner, the results will usually be poor. This can be seen from a quick examination of the process ink gamut chart. Since most of the colors scan as black, parts of most pictures will scan as black-on-black. This usually results in a loss of detail in a picture.

When color printing must be scanned, it is advisable to individually scan each sheet and adjust the scanner threshold for the best representation of that sheet.

NOTE: Color filtering systems may be incorporated into the scanning system to produce better reproduction. The amount of improvement obtained (if any) will vary between scanners, and from picture to picture.

A collection of scanned and printed output of the process ink gamut chart scanned at various settings should be maintained to keep track of how the user's individual system reproduces color.

9.3 Procedure

To use the process ink gamut target, adjust the scanner threshold and scan the target.

There are two ways of evaluating the target. For normal use, the target is a good indicator of the threshold setting. If the same circles are black, gray, and white as on the quality reference, the threshold is probably set properly. For use testing color blindness, check the circle on the scanned copy which most closely matches the color of interest on the original. Ideally, it should be dark gray. (Other than for a general check, the better method is to scan the document of interest and adjust the scanner to get the best image.)

APPENDIX A. Producing a User Target

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988.)

A1. Producing a User Target

This appendix describes test targets that a user can create from materials at hand. This user target supplements the recommended test targets by including test objects which are representative of the user's unique environment.

The recommended test objects are ideal targets in that they are black images on clean white paper. They are useful because these images are consistent, and therefore can be used to measure the consistency of the system. The real world of scanning documents, however, does not confine itself to ideal images. Some of the nonideal things encountered will be:

coffee stains
color logos and letterheads
color photographs
color type
colored papers
creased or wrinkled paper
dirty originals
dot-matrix printing
facsimile machine output
faded originals
fingerprints
glossy paper
highlight pen markings
maps
carbonless copies (various colors)
non-white "white" paper
textured paper
thin paper (onion skin)
torn and taped paper
two-sided printing with show-through
type on colored ink backgrounds
watermarks
weak carbon copies
and any combination of these items and other conditions.

Before scanning large numbers of documents with any of these characteristics, it is important to know what the scanner will do with them, and how to set up the scanner to produce the best image possible.

For example, an organization using pale brown textured stationery (such as laid or pebble surface), which has to scan correspondence, should have the scanner adjusted so that the brown textured background is below the scanner threshold and appears white to the scanner. If that organization also uses a brown typewriter ribbon, the scanner threshold must also be set below the ribbon color, so that the image is seen as black on white. (If the ribbon color falls in the color-blind range of the scanner, the options are to choose another color ribbon, choose another scanner, or copy each page and scan the copies.)

A2. Recommended Procedure

The user should create a target or a number of targets that represent documents typically encountered. The target should be composed of strips of material having the required characteristics, mounted on a sheet of bond paper (copier paper). The strips can be as wide as necessary, up to the full page, but usually 1/2 inch to 1 inch strips will provide a sufficient test of a given material.

The image test strips should be oriented so that the direction of the scan is along the long dimension of the strip. If the scanner is a type that moves the document, the edges of the strips should be carefully taped down. Double-sided tape is best for this; normal transparent tape may affect the scanning of the areas it covers.

The reason that strips are recommended rather than patches is that some scanners use a technique known as adaptive thresholding. This technique allows the scanner to better recognize thin lines, but will sometimes react poorly to abrupt changes in background color as would be the case with side-by-side patches.

If space allows, a typed description under each strip telling the operator what to look for is extremely useful.

As an alternative to creating a strip target, individual samples of problem pages can be created or selected as targets. This may give a more representative test of the problems found on a particular form at the expense of having more targets to scan.

If all types of documents are to be scanned without changing the scanner settings, then the test target or set of targets should include all of the characteristics of the full range of images likely to be encountered. Experience will show which test images will be the most sensitive to which adjustments (or misadjustments) of the scanner.

When scanner adjustments are made between scan batches of different types, a separate scan target for each batch type should be used in order to avoid confusion. (For example, one target for no carbon required (NCR) goldenrod, another for NCR pink, another for typed originals, and so on.)

APPENDIX B. Scanner Test Results Log

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988.)

The following page contains a sample log sheet as described in Section 4.5. The figure caption is omitted so that the page may be photocopied for use in quality control procedures.

APPENDIX C. Possible Help for Unscannable Documents

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1989.)

Some documents cannot be scanned with any prospect of capturing a reasonable image unless some form of enhancement is used. Examples of difficult materials include some maps, documents deliberately not intended to be copied (special reports, etc.), and documents where the scanner sees the foreground and the background as the same color. This appendix gives some tips that may help produce a satisfactory image of some material in some cases.

One method that will work for some documents is to photocopy the document and scan the photocopy. While some detail may be lost, enough of the image may remain to be adequate for the purpose intended. Many maps fall into this category.

Note that photocopy machines are usually color-blind in at least one color and they also have thresholds, although these thresholds are less adjustable than those of a scanner. If the color you need to bring out of a color original is invisible to your copier, try a different model or brand of copier. You will often get different results.

A second method of bringing out some colors is to place a colored filter in the optical path of the scanner. The same effect may be obtained by placing a colored transparent sheet over the image. If this does not work on the scanner, try it on a photocopier.

Continuous-tone photographs usually will not scan well. Placing a layer of 65 mesh halftone screening material over the picture on the scanner will sometimes produce a good image. If not, try the material on a copier and scan the copy. If the scanner vendor has supplied screen material, follow the vendor's instructions.

APPENDIX D. Resolution Targets

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988.)

Resolution targets can take on a variety of forms, but most often they consist of groups of white and black parallel lines. An example is shown in Figure D1. For any particular group, the width of the black lines is the same as the width of the white spaces between the lines. A group will also usually consist of both vertical lines and horizontal lines. A complete resolution target is then a collection of groups, where the width of the lines and spaces is smaller and smaller for each successive group.

This type of line pair resolution test target was developed to test complete photographic recording systems or their components. It typically cannot be used to test image resolution for systems comprised of digital scanners and printers which sample discrete areas, or pixels, of an image.

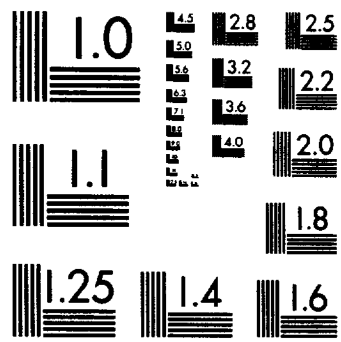

Figure D1. Resolution Target

In order for images to be stored in computers and/or transmitted electronically, the images must be sampled and the samples converted to a sequence of numbers. The sampling process is like laying a window screen on top of a typical business document where each rectangular hole in the screen represents a sample. Each sample is then converted to a number depending on the shade of gray visible through the hole. For instance, white may be 0, black may be 100, light gray may be 35, and dark gray may be 70.

Now consider what happens when the window screen is placed on top of a resolution target. For groups which have very wide lines each sample will probably be almost

SCANNER TEST RESULTS LOG

DATE	INITIALS	SETTINGS	RESULTS	COMMENTS

all black or all white. Or in other words, the sample values will either be 0 or 100. For groups that have very small lines, such that two or three sets of lines may fit inside one sample, then the value of each sample will be some average between white and black or around 50. Clearly, for this case individual lines cannot be distinguished because only one sample is being used to represent several lines. What about the case where the width of the sample is the same width as the line? At first one may think this is ideal, and assume the result would be one black sample followed by one white sample followed by one black sample, and so on. However, since the placement of the samples can not be precisely controlled, sometimes the sample will be in the center of the line and sometimes it will be on the edge of the line as shown in Figure D2. When it is on the edge, the sample area will contain half black and half white and the value will be around 50 on this scale! So, if the samples are in the center of the lines then, indeed, the result will be black, white, black, white, etc., and they will be distinguishable. However, if the samples are on the edges then the result will be gray, gray, gray, etc., and they will not be distinguishable. Unfortunately, the outcome is simply a matter of chance!

The term normally given to the image defect described here is aliasing, and the visible pattern which is created is called moire. Moire is interference of one pattern with another, and shows as a beat frequency between the two patterns. In the example above, where the line spacing and scan spacing are identical, the beat frequency is zero, and the success or failure of the scan will depend on whether the scan is in phase with the image.

Another image defect that can appear in scanning targets as a result of aliasing is a discontinuity in a line which is close to horizontal or vertical, caused when a thin image moves from being recognized by one scan line to another. In scanning targets, this can make some targets appear to be resolved when what is actually being seen is a false line caused by the aliasing rather than the actual image line.

There are other factors that can affect the output. These include, among other things, the threshold setting. The threshold, which is discussed in more detail later, is most often adjusted to detect light lines, for example, but ignore dirt, dust, and other image defects. Suppose your standard threshold setting which achieves this is 25, on a scale of 0 to 100. But, as described previously, the placement of the samples on the resolution target leads to alternating values of 35, 65, 35, 65, etc. Then all the samples would be above the threshold and come out black! However, if the threshold is raised to 50 then the samples will alternate white, black, white, black, etc.

Therefore, using line/space resolution targets to test scanning systems is not advised due to:

(1) The problems associated with the random placement of the samples, and

(2) The conflicting requirements placed on the threshold.

On one scan the output target may look sharp and on the next it may look broken or filled in when, in fact, nothing has changed!

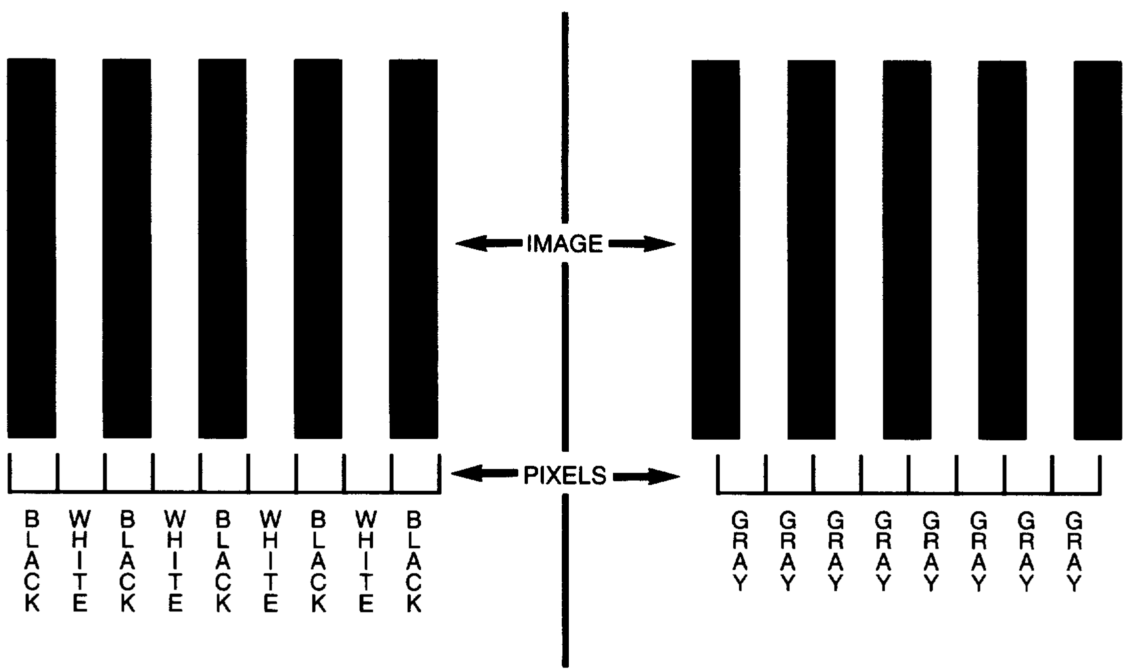

Figure D2. Example of Sampling Problem

APPENDIX E. Thresholding and Enhancement

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988.)

What is the threshold in a scanning system and how does it affect output? Simply stated, the threshold setting determines what parts of the image will be black and what parts will be white. More specifically, when an image is scanned it undergoes a process called sampling. Sampling consists of overlaying the image with an imaginary grid. Each hole in the grid represents a sample which is converted to a number depending on the shade of gray visible through the hole. White may be converted to 0, while black is converted to 100, and gray to 50. The threshold will also be represented by a number between 0 and 100.

In a simple thresholding system, each sample is compared independently with the threshold. Those samples which have a value greater than the threshold are output as black and those less than the threshold are output as white. Therefore, if the threshold is lowered it is likely that more samples will be greater than the threshold and so more samples will be output as black. If the threshold is raised, then the opposite will be true and more samples will be output as white. The brightness of the light source in the scanner can also affect what is converted to black or white. Drifts in the settings can indicate potential problems. If one finds that they are gradually shifting the threshold in the same direction over a long period of time to maintain acceptable images, then perhaps the lamp(s) are fading and should be serviced.

Typically, the threshold is set low enough so that light features in the image, such as light pencil marks, will be detected and converted to black, but high enough so that dust, dirt, and other unwanted image defects will not be detected. On some occasions, however, no single threshold setting will result in an acceptable image. That is to say, at a high setting some parts of the image go completely undetected, while at a low setting other parts of the image go totally black. As shown in Figure E1, a portion of the business form has been shaded to designate OFFICE USE ONLY. However, the name of the provider, Dr. Sawyer, has been written so lightly that it is lighter than the shading (this could easily happen with carbon copies). Therefore, either the left half of the document will be legible or the right half, but not both.

In many cases, such as the one described, some form of image enhancement may be helpful. Image enhancement may take many forms, but the primary purpose is to improve the readability of an image. One should be aware, however, that any type of image enhancement also carries with it the risk of degrading the image.

Typical types of image enhancement include black spot (or orphan) removal, image sharpening, and adaptive thresholding. Briefly, black spot removal normally involves suppressing random isolated black spots that are not part of the original image, but which may occur due to a low threshold setting. This usually improves the appearance of the image by making it look cleaner, however it also occasionally degrades an image containing faint broken lines, small isolated characters and/or handwriting. Image sharpening, or edge enhancement as it is sometimes referred to, strives to make the image look sharper by emphasizing edges, lines, and small image details. Unfortunately, this sometimes causes small unwanted image details to be detected making the image look dirty. Finally, adaptive thresholding usually involves some technique for automatically adjusting the detection threshold to accommodate local contrast variations, such as writing over a coffee stain.

Referring to the example of the coffee stain, an adaptive threshold scheme would choose one threshold on the unstained portion of the page, and a higher threshold on the stained portion of the image. Sometimes, however, the adaptive threshold may become confused and choose an undesirable threshold, yielding a poor image. Some scanners with adaptive thresholding have difficulty detecting very thin black lines or very thin white lines on black backgrounds.

In summary, imaging systems that have devices such as scanners, digital printers, and displays require that the images be represented as a sequence of samples. These systems prefer that the samples be either black or white. Since many documents are not simply black and white, this requires that a decision be made based on a threshold. Consequently, the choice of the threshold setting can have a large impact on image quality. Many manufacturers provide various forms of image enhancement to help compensate for the constraints imposed by sampling and thresholding. Unfortunately, these enhancement techniques can occasionally degrade the output, therefore their impact must be judged with care.

[redacted]

03 PATIENT FIRST NAME: CATHY | PATIENT LAST NAME: SMITH | RELATIONSHIP TO SUBSCRIBER: ☒ SELF ☐ SPOUSE ☐ CHILD | SEX: ☐ M ☒ F | PATIENT BIRTH DATE MO. DAY YR.: 09 09 57

04 Kmed IDENTIFICATION NUMBER: 779207652 | SUBSCRIBER FIRST NAME: CATHY | M.I.: R | SUBSCRIBER LAST NAME: SMITH

05 SUBSCRIBER HOME ADDRESS—HOUSE NUMBER, STREET, CITY: 12769 ELM ROAD, SMITHTOWN | STATE: VT | ZIP CODE: 07924

IS PATIENT COVERED BY MEDICARE? ☒ YES ☐ NO

BE SURE TO ENCLOSE YOUR EXPLANATION OF MEDICARE BENEFITS STATEMENTS.

IF YES, SUPPLY MEDICARE HEALTH INSURANCE BENEFIT NUMBER: 123123123T

TELEPHONE NUMBER: (101) 555-2907

IS THE PATIENT ENTITLED TO BENEFITS FOR THESE SAME EXPENSES UNDER ANY OTHER GROUP INSURANCE PLAN? ☐ YES ☒ NO

IF YES, FROM WHOM?

WAS PATIENT PREVIOUSLY COVERED BY KODAK EXTENDED HEALTH CARE PLAN (KEHCP)? ☐ YES ☒ NO IF YES, →

KODAK INSURANCE #

BRIEF DESCRIPTION OF ILLNESS/INJURY RELATING TO THIS CLAIM: SWOLLEN ANKLE

[redacted]

09 WHEN AND WHERE DID ACCIDENT HAPPEN? MONTH DAY YEAR | CITY | STATE

WAS PERSON AT WORK WHEN ACCIDENT HAPPENED? ☐ YES ☒ NO

WAS PERSON IN AUTO ACCIDENT? ☐ YES ☐ NO

BRIEF DESCRIPTION OF ACCIDENT:

[redacted]

IS DEPENDENT EMPLOYED? ☐ YES ☐ NO | IF YES, NAME OF EMPLOYER | ADDRESS OF EMPLOYER

IS THE DEPENDENT A FULL-TIME STUDENT AGE 19-22? ☐ YES ☐ NO | IF YES, NAME OF SCHOOL

[redacted]

AMOUNT BILLED	[redacted]	DATE OF SERVICE	NAME OF PROVIDER OF SERVICE	[redacted]
$250.00		10/17/89	Dr. Sawyer	

06 $ 250.00 ◄ TOTAL CLAIM CHARGES

Figure E1

APPENDIX F. Additional Information on Color Objects

(This appendix is not a part of American National Standard for Information and Image Management—Recommended Practice for Quality Control of Image Scanners, ANSI/AIIM MS44-1988.)

This appendix is intended to give the user some insight into the problems involved not only in scanning color, but in addressing color in technical terms.

When most people speak of color they are using a general term to describe the perception of certain wavelengths of the electromagnetic spectrum. In discussing the scanning of objects which are not black images on white paper, it is important to realize that there are a number of application areas for color and that colors in each of these areas are produced in different manners and may not actually be the same. These areas are:

(1) Printing (offset, gravure, letterpress, etc.)
(2) Photography
(3) Ink jet
(4) Color xerography
(5) Ribbon printing
(6) Paper colors

The color spectrum is defined in terms of reflectivity and wavelength of light reflected from or transmitted through objects. The following reference is used in defining color names:

Kodak Color Separation Guides, Kodak Publication No. Q-14.

There are a number of currently available targets for color:

(1) Process Ink Gamut Chart (RIT) (Test target 3 described in this practice and available from AIIM)

(2) Pantone, Ink Color Samples

(3) Kodak Color Separation Guide, Q-14

(4) Dataquest Color Target (or similar color copier targets)

ANSI/AIIM MS44-1988

1100 Wayne Avenue, Suite 1100
Silver Spring, MD 20910
301/587-8202
ISBN 0-89258-167-0

Printed in the United States of America

ISBN 0-89258-167-0

May 1989