Designation: F1851 – 98 (Reapproved 2009)

Standard Practice for Bar Code Verification[1]

This standard is issued under the fixed designation F1851; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes a specific procedure for using a bar code verifier to measure and quantify the optical and symbology characteristics relative to the print quality of a bar code symbol and its performance within a bar code reading system. Measurements taken with bar code verifiers should conform to ANSI ANS X3.182–1995 [R] methodology. Various printing methods including direct thermal, thermal transfer, electrophotographic, dot matrix, and ink jet methods are used to produce bar code symbols. Use of this procedure will help assure repeatability of measurements between operators and pieces of equipment and traceability of those measurements.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1294 Terminology Relating to Automatic Identification Hard Copy Printing Systems

2.2 *ANSI Standard:*

ANSI ANS X3.182–1995 [R] Bar Code Print Quality Guideline[3]

2.3 *AIM Standard:*

AIM USA Layman's Guide to ANSI Print Quality[4]

2.4 *Military Standard:*

MIL-STD 105E Sampling Procedures and Tables for Inspection by Attributes[5]

3. Summary of Practice

3.1 Printed bar codes can be analyzed with commercially available bar code verifiers to generate measurement values relative to print quality. Verifiers can have various optical input devices and operate in varied spectral ranges with apertures of differing sizes. The validity of the results of verification can be affected greatly by the selection of the equipment, spectral response and aperture size, as well as the operator's use of the equipment. Reporting structure of the test results (symbol grade) only has meaning when the measuring aperture number and nominal wavelength also are specified. The methodology contained within this test method offers both a standard series of procedures for equipment set-up and use, and general recommendations, guidelines and information on bar code verification.

4. Significance and Use

4.1 This test method provides a way to measure and quantify bar code print quality using commercially available bar code verifiers. Possible uses include the following.

4.1.1 Performance comparisons between media supplied by different manufacturers.

4.1.2 Performance comparisons between imaging materials supplied by different manufacturers.

4.1.3 Performance comparisons between printers supplied by different manufacturers.

4.1.4 Performance comparisons between different printing methods.

4.1.5 Research and development evaluation of developmental coatings, ribbons and media for various printing methods for bar code imaging.

4.1.6 Manufacturing process control can use this test method to audit product performance.

5. Interferences

5.1 To avoid interference from external causes, no laminates, overcoats or protective materials should be used on or

---

[1] This practice is under the jurisdiction of ASTM Committee F05 on Business Imaging Productsand is the direct responsibility of Subcommittee F05.03 on Research.

Current edition approved Oct. 1, 2009. Published October 2009. Originally approved in 1998. Last previous edition approved in 2003 as F1851 – 98(2003). DOI: 10.1520/F1851-98R09.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from AIM USA, 634 Alpha Dr., Pittsburgh, PA 15238.

[5] Available from Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094.

Copyright © ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959. United States

over the samples. These may cause verification results that are not characteristic of the process being tested.

5.2 The equipment selected should be set-up, programmed (if necessary) and calibrated to the manufacturers recommendations.

NOTE 1—This is extremely important as improper use of verification equipment through incorrect set-up or calibration, or both, can cause misleading results.

5.3 To avoid interference caused by operating power voltage fluctuations, the equipment used should be operated using the power source recommended by and in the manner recommended by the manufacturer. In the event results can vary with variation in supply power, such as if the unit operates solely from batteries, it should be determined what results variations can be expected, based upon the manufacturer's recommendations, and appropriate compensation should be made.

6. Procedure

6.1 *Calibration/Traceability:*

6.1.1 Proper calibration is an essential aspect of the operation of a bar code verifier. It is imperative that the operator properly and carefully follow the manufacturer's procedures for calibration of the verifier. Frequency of calibration should be recommended by the manufacturer, and calibration at a frequency greater than recommended may ensure higher accuracy and repeatability.

6.1.2 To assist in determining if a verifier is being operated within the ANSI ANS X3.182–1995 [R], bar code calibration or correlation standards are available.[6]

6.2 *Test Materials:*

6.2.1 Test specimens should be characteristic or representative of output from a specific process. Appropriate bar code symbols should be imaged on the media to be tested.

6.2.2 Test specimens and samples should be handled with care. Defects in the samples should be characteristic of the process being tested and not due to handling of the specimens.

6.3 *Equipment Selection and Use*

6.3.1 Bar code verifiers can consist of various pieces of equipment with differing capabilities and features. Users should select a device that meets the operational, application, and specification requirements of their application. Particular attention should be paid to what application or industry standard(s) the device must measure against and that the optical input device be matched to the type of materials to be tested.

6.3.2 The aperture size and wavelength has a significant impact as to the grade results obtained. The ANSI Guideline X3.182–1995 [R] recommends the aperture diameter based on the "X" dimension of the bar code being verified. The aperture and wavelength specified in industry application standards takes precedence over the ANSI guideline, even if some "X" dimension ranges do not agree with the ANSI recommendations. If measuring aperture diameter is not specified, select aperture diameter based upon the ANSI ANS X3.182–1995 [R] recommendations shown below.

Diameter	"X" Dimension (in 0.0010 in.) Range
0.0030 in.	0.0040 to 0.007 in.
0.0050 in.	0.0071 to 0.013 in.
0.0100 in.	0.0131 to 0.025 in.
0.0200 in.	0.0251 in. and larger

6.3.3 The equipment selected should be set-up, programmed, if necessary, and calibrated to the manufacturers recommendations.

NOTE 2—This is extremely important as improper use of verification equipment through incorrect set-up, or calibration, or both, can cause misleading results.

6.3.4 Care should be taken in the selection of the location where verification is performed. The operator should be aware of unusual ambient light conditions that may affect readings. Additionally, calibration of the device should be performed under the same ambient lighting conditions as those where the testing will be performed. The infinite pad method referenced in ANSI ANS X3.182–1995 [R] should be used to prevent optical affects caused by the opacity of the sample substrate. In the absence of materials for the infinite pad method, an opaque black matte surface can be used under the test sample to provide a worse case optical situation.

6.3.5 Bar code symbols should be scanned in both directions (left to right and right to left) and over numerous areas of the symbol. This practice will ensure a better overall indication of the bar code symbols total quality.

6.3.6 Operator proficiency can influence the results. Operators must be trained and care should be taken in all testing situations. It is recommended that statistical methods be employed to reduce the effects of operator variability and that operators undergo periodic retraining. As a quality measurement function, bar code verification should be approached the same as any other quality control or quality monitoring function.

6.3.7 ANSI ANS X3.182–1995 [R] specifies ten scans of a symbol are required to obtain a symbol grade. The number of symbol grades or scans taken from a particular test sample should be based upon statistical methodology to ensure the results meet the necessary levels of confidence required. Please refer to MIL-STD 105D for guidance on sampling levels and techniques.

7. Report

7.1 A Scan Reflectance Profile (SRP) is a record of the reflectance values (0 % to 100 %) measured along a single line across the entire width of the bar code. These values are charted to create an analog representation of the bar code. The scan reflectance profile grading method identifies relative levels of print quality. Each SRP will be graded as A, B, C, D, or F (Scan Grade) for one or possibly more of specified criteria. The grading scheme follows academic letter grades A, B, C, D, and F where A is the best grade and F the lowest. After creating

[6] As an adjunct to the ANSI standard, the Uniform Code Council and AIM USA, created a unique set of primary and secondary Bar Code Calibration Standards in conjunction with Applied Image, Inc. These bar code standards are calibrated to ANSI Methodology and traceable to NIST. Though verifier manufacturers also may have NIST traceable calibration/correlation standards available, the sole source of supply of these test standards known to the committee at this time is Applied Image, Inc., 1653 East Main Street, Rochester NY 14609. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

the SRP, a count of the elements (bars and spaces) determines if the bar code conforms to some type of symbology, but before this can be accomplished, edge determination must be done.

7.1.1 *Edge Determination*—A Global Threshold is established halfway between the highest reflectance value and the lowest reflectance value seen in the profile. Edge determination is done by counting the number of crossings at the Global Threshold confirming whether the count conforms to or is considered nonconforming to a legitimate bar code symbology. If the bar code conforms it PASSES (Grade A); if it is considered nonconforming it FAILS (Grade F). The formula is as follows:

$GT = R_{min} + SC/2$,
R_{min} = Reflectance Min, and
SC = Symbol Contrast.

7.1.2 *Decode*—A bar code will PASS on Decode when the established bar and space widths can be converted into the correct series of valid characters using the Reference Decode algorithm for a given symbology and or application and is graded Pass (A) or Fail (F).

7.1.3 *Minimum Reflectance* (R_{min})—The reflectance value for at least one bar must be half or less than the highest reflectance value for a space and is graded Pass (A) or Fail (F). The formula is as follows:

$$R_{min} \leq .5\ R_{max} = \text{PASS},\ R_{min} > .5\ R_{max} = \text{FAIL}$$

where:

R_{min} = Reflectance min, and
R_{max} = Reflectance max.

7.1.4 *Minimum Edge Contrast* (EC_{min})—Each transition from a bar to a space, or back again, is an "edge" whose contrast is determined as the difference between peak values in that space and that bar. The edge that has the minimum contrast from the transition from space reflectance to bar reflectance, or from bar to space, is the Minimum Edge Contrast or EC_{min} and is graded Pass (A) or Fail (F). The formula is as follows:

$$EC_{\text{min}} = Rs_{\text{min}} - Rb_{max} \text{ (worst pair)}$$

where:

Rs = Space Reflectance, and
Rb = Bar Reflectance.

7.1.5 *Symbol Contrast (SC)*—Symbol contrast is the difference between the highest reflectance value and the lowest reflectance value in the scan profile and is graded A, B, C, D, or F. The quantitative criteria for the symbol contrast grades are given in ANSI ANS X3.182–1995 [R]. The formula is as follows:

$$SC = R_{max} - R_{min}$$

where:

SC = Symbol Contrast,
R_{max} = Reflectance Max, and
R_{min} = Reflectance Min.

7.1.6 *Modulation (MOD)*—Modulation has to do with how a scanner sees wide elements (bars or spaces) in relationship to narrow elements, as represented by reflectance values in the scan profile. Scanners usually see spaces narrower than bars, and scanners typically see narrow spaces being even less intense or not as reflective as wide spaces and is graded A, B, C, D, or F. The quantitative criteria for the modulation grades are given in ANSI ANS X3.182–1995 [R]. The formula is as follows:

$$EC_{min}/SC$$

where:

EC_{min} = Edge Contrast Min, and
SC = Symbol Contrast.

7.1.7 *Defects*—Defects are voids found in bars or spots found in the spaces and quiet zones of the code. Voids, spots, smudges, and other defects in bar code symbols can yield poor scanning results, and thus, will yield lower verification results. Each element is evaluated individually for its reflectance nonuniformity. Element reflectance nonuniformity is the difference between the highest reflectance value and the lowest reflectance value found within a given element and is graded A, B, C, D, or F. The quantitative criteria for the defect grades are given in ANSI ANS X3.182–1995 [R]. The formula is as follows:

$$ERN_{max}/SC$$

where:

ERN_{max} = Element Reflectance Nonuniformity, and
SC = Symbol Contrast.

7.1.8 *Decodability*—Decodability is the measure of the accuracy of the printed bar code against the appropriate reference decode algorithm. Each symbology has published dimensions for element widths and provide margins or tolerances for errors in the printing and reading process. Decodability measures the amount of margin left for the reading process after printing the bar code. Different decodability calculation methods are used for each type of symbology being tested. The decodability calculations are programmed into the verifiers, and decodability is graded A, B, C, D, or F according to the quantitative criteria for the decodability grades given in ANSI ANS X3.182–1995 [R] or in supplemental industry standards.

7.1.9 *Overall Profile Grade*—The lowest grade received by any of the following parameters; edge determination decode, minimum reflectance, symbol contrast, modulation, decode and decodability.

7.2 *Scan Grade*—The lowest grade received for any quality parameter in a scan reflectance profile. For example, if a grade of A or PASS is received for all quality parameters except for Modulation, which received a grade of C, the overall Scan Grade is C. Ten SRP Scan Grades are recommended to determine the symbol grade. The reason for averaging ten scans is purely for vertical redundancy. Quality levels may vary within the height of the bar code symbol being verified; however, the methodology used to scan or read bar codes allows symbols with isolated areas of poor quality to be acceptable for many applications.

7.3 *Symbol Grade*—The simple average of all the overall scan grades (profile grades) using the standard weighting of A = 4.0, B = 3.0, C = 2.0, D = 1.0, and F = 0.0. The symbol grade may be stated as a decimal or letter grade.

3.5 ≤ A ≤ 4.0
2.5 ≤ B ≤ 3.5
1.5 ≤ C ≤ 2.5
0.5 ≤ D ≤ 1.5
F < 0.5

7.4 A symbol grade only has meaning when the measuring aperture number and nominal wavelength also are specified. The format for denoting symbol grade is: "Symbol Grade" followed by a slash (/) followed by the "Measuring Aperture Number" followed by a slash (/) followed by the nominal wavelength in nanometers, that is, C/10/660 or 2.4/10/660. The measuring aperture number is the aperture diameter expressed in inches, divided by 100.

7.5 Alternate or additional measurement values, such as print contrast signal (PCS) and dimensional tolerances also are measured. These values have historic precedence. Symbols, which offer good, reliable performance, may fail PCS or dimensional tolerances, or both.

7.6 A symbol grade only has meaning when the measuring aperture and nominal wavelength also are specified. The format is: "Symbol Grade"/"Aperture"/"Wavelength" (for example, B/06/660). Use this format when reporting results.

7.7 The key value to report is overall symbol grade (numeric value 4.0 to 0.0).

7.8 Additional information, such as sample substrate, ambient temperature/relative humidity/light measurement, verifier/imaging system used, date, time and operator should be included as part of the test report.

8. Keywords

8.1 bar code; decodability; defects; modulation; print quality; scan grade; scan reflectance profile; symbol contrast; symbol grade; verification; verifier

APPENDIX

(Nonmandatory Information)

X1. RATIONALE

X1.1 *Significance of Grade Level*—Bar code systems can provide good performance with differing symbol grades because of the following: vertical redundancy; tolerances built into decoding algorithms; the ability of operators to rescan if the first read is unsuccessful; and, the availability of scanning devices that provide for multiple, unique scan paths across the code.

X1.2 The different symbol grades indicate print quality. An application specification shall identify the minimum acceptable grade level including the measuring aperture and the nominal wavelength(s).

X1.2.1 Symbols with a Grade A are the best quality and will in general give the best performance. In general, this grade symbol is appropriate for systems in which the reader crosses the symbol once or is limited to a single path.

X1.2.2 A symbol with a Grade B may not perform to the same level as one with a Grade A. Some B symbols may need to be rescanned. In general, this grade is best suited for applications, which require symbols to be read most of the time in a single pass of a bar code scanner but allow for rescan.

X1.2.3 Symbols of Grade C may require more rescans than those of Grade B. In general, these Grade C symbols may need more frequent rescanning and for best read performance a device that provides for multiple, unique scan paths across the code should be used.

X1.2.4 A symbol of Grade D is best read by bar code readers that provide for multiple, unique scan paths across the symbol. There may be symbols with a Grade D that certain readers can not read. Prior to selection of a Grade D symbol for a particular application, it is advised that the symbol(s) should be tested with the type of bar code reader expected to be used. The test(s) will establish that the read results are within acceptable limits and expectations.

ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.

This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org). Permission rights to photocopy the standard may also be secured from the ASTM website (www.astm.org/COPYRIGHT/).