International Standard

ISO/IEC 15416

Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols

Techniques automatiques d'identification et de capture des données — Spécifications pour essai de qualité d'impression des codes à barres — Symboles linéaires

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This third edition cancels and replaces the second edition (ISO/IEC 15416:2016), which has been technically revised.

The main changes are as follows:

— the calculation of threshold to find edges within a scan reflectance profile has been modified;

— the calculation of R_{max} and R_{min} has been modified;

— the calculation of continuous grades has been clarified.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

The technology of bar coding is based on the recognition of patterns encoded in bars and spaces of defined dimensions according to rules defining the translation of characters into such patterns, known as the symbology specification.

The bar code symbol is produced in such a way as to be reliably decoded at the point of use, if it is to fulfil its basic objective as a machine-readable data carrier.

Manufacturers of bar code equipment and the producers and users of bar code symbols therefore require publicly available standard test specifications for the objective assessment of the quality of bar code symbols, to which they can refer to when developing equipment and application standards or determining the quality of the symbols. Such test specifications form the basis for the development of measuring equipment for process control and quality assurance purposes during symbol production, as well as afterwards.

This edition of this document introduces several new methods of grading bar code symbols that will improve the stability of results and modernize the grading method to be more in alignment with modern methods of bar code scanning. Further details about the changes made in this edition of this document are discussed in Annex K.

The performance of measuring equipment is covered in ISO/IEC 15426-1.

This document is intended to be read in conjunction with the symbology specification applicable to the bar code symbol being tested. The symbology-specification provides symbology specific details. Additionally, an application specification is required to apply this document.

This methodology provides symbol producers and their trading partners a universally standardized means for communicating about the quality of bar code symbols after they have been printed.

Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols

1 Scope

This document

— specifies the methodology for the measurement of specific attributes of bar code symbols,

— defines a method for evaluating these measurements and deriving an overall assessment of symbol quality, and

— gives information on possible causes of deviation from optimum grades to assist users in taking appropriate corrective action.

This document applies to those symbologies for which a reference decode algorithm has been defined, and which are intended to be read using linear scanning methods, but its methodology can be applied partially or wholly to other symbologies.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 19762, *Information technology — Automatic identification and data capture (AIDC) techniques — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
bar reflectance
lowest reflectance value in the scan reflectance profile of a bar element

3.2
defect
irregularity found within elements and quiet zones

3.3
edge contrast
difference between *bar reflectance* (3.1) and *space reflectance* (3.13) of two adjacent elements

3.4
element reflectance non-uniformity
reflectance difference between the highest *peak* (3.9) and the lowest *valley* (3.15) in the scan reflectance profile of an individual element or quiet zone

3.5
global threshold
reflectance level used for the initial identification of elements

Note 1 to entry: to entry. The global threshold is determined by the procedure in Annex B.

3.6
inspection band
band (usually from 10 % to 90 % of the height of a bar code symbol) across which measurements are taken

Note 1 to entry: For an illustration of an inspection band, see Figure 2.

3.7
measuring aperture
aperture
opening which governs the effective *sample area* (3.10) of the symbol, and the dimensions of which at 1:1 magnification is equal to that of the sample area

Note 1 to entry: For an illustration of a measuring aperture, see Figure 1.

3.8
modulation
ratio of the minimum edge contrast to symbol contrast

3.9
peak
point of higher reflectance in a scan reflectance profile with points of lower reflectance on either side

3.10
sample area
effective area of the symbol within the field of view of the measurement device

3.11
scan path
line along which the centre of the *sample area* (3.10) traverses the symbol, including quiet zones

3.12
space
light element corresponding to a region of a scan reflectance profile above the *global threshold* (3.5)

3.13
space reflectance
highest reflectance value in the scan reflectance profile of a space element or quiet zone

3.14
symbol contrast
difference between the maximum and minimum reflectance values in a scan reflectance profile

3.15
valley
point of lower reflectance in a scan reflectance profile with points of higher reflectance on either side

4 Symbols and abbreviated terms

4.1 Symbols

A	average achieved width of element or element combinations of a particular type
c	defect adjustment constant
E	width of narrowest wide element
e	width of widest narrow element
D_F	defects
e_i	i^{th} edge to similar edge measurement, counting from leading edge of symbol character
F	factor used to soften the effect on defect grades derived from small changes peaks and valleys within an element
K	smallest absolute difference between a measurement and a reference threshold
k	number of element pairs in a symbol character in a (n, k) symbology
M	width of element showing greatest deviation from A
m	number of modules in a symbol character
N	average achieved wide to narrow ratio
N	number of modules in a symbol character in a (n, k) symbology
P_{CS}	print contrast signal
R_b	bar reflectance
R_D	dark reflectance
R_L	light reflectance
R_{max}	maximum reflectance
R_{min}	minimum reflectance
R_{MOD}	modulation
R_s	space reflectance
ΔR_{Emin}	minimum value of edge contrast
ΔR_{SC}	symbol contrast
ΔR_{Nmax}	maximum element reflectance non-uniformity
t	Grey-scale value
D_T	reference threshold between narrow and wide element widths for two-width symbologies
T_j	reference threshold between measurements j and (j + 1) modules wide
T_G	global threshold between bars and spaces

S total width of a character

V decodability value for a scan

V_1 decodability intermediate value above

V_2 decodability intermediate value below

V_C decodability value for a symbol character

Z average achieved narrow element dimension or module size, as measured

4.2 Abbreviated terms

EC edge contrast

ERN element reflectance non-uniformity

GT global threshold

MOD modulation

PCS print contrast signal

SC symbol contrast

SRP scan reflectance profile

5 Measurement methodology

5.1 General requirements

The measurement methodology defined in this document is designed to maximize the consistency of both reflectivity and bar and space width measurements of bar code symbols on various substrates. This methodology is also intended to correlate with conditions encountered in bar code scanning hardware.

Measurements shall be made with a defined light source (such as a single light wavelength) and a measuring aperture of dimensions defined by the application specification or determined in accordance with 5.2.2 and 5.2.3. A circular aperture is defined by its diameter in accordance with Table 1. Application specifications may define other aperture diameters or shapes.

Whenever possible, measurements shall be made on the bar code symbol in its final configuration, i.e. the configuration in which it is intended to be scanned. If this is impossible, refer to Annex D for the method to be used for measuring reflectance for non-opaque substrates.

This document defines the method of obtaining a quality grade for individual symbols. Annex H provides an example of a report that contains the overall grade and other measurements made by a device which implements the method described in this document. The use of this method in high volume quality control regimes can require sampling in order to achieve the desired results. Such sampling plans, including required sampling rates are outside of the scope of this document.

NOTE Information on sampling plans can be found in ISO 3951-1, ISO 3951-2, ISO 3951-3, ISO 3951-5 and ISO 28590.

5.2 Reference reflectivity measurements

5.2.1 General

The equipment for assessing the quality of bar code symbols in accordance with this document shall comprise a means of measuring and analysing the variations in the diffuse reflectivity of a bar code symbol on its substrate along a number of scan paths which shall traverse the full width of the symbol including both quiet zones. The basis of this methodology is the measurement of diffuse reflectance from the symbol.

All measurements on a bar code symbol shall be made within the inspection band defined in accordance with 5.2.5.

The measured reflectance values shall be expressed in percentage by means of calibration to a reference reflectance standard traceable to national measurement institutes.

NOTE Maximum diffuse reflectance, traditionally comparable to barium sulphate or magnesium oxide, is taken as 100 %.

5.2.2 Measurement light source

The light source used for measurements should be specified in the application specification to suit the intended scanning environment. When the light source is not specified in the application specification, measurements should be made using the light source that approximates most closely to the light source expected to be used in the scanning process. Light sources may include narrow band or broad band illumination. Refer to Annex F for guidance on the selection of the light source.

5.2.3 Measuring aperture

The nominal diameter of the measuring aperture should be specified by the user application specification to suit the intended scanning environment. In an application where a range of X dimensions can be encountered, all measurements shall be made with the aperture(s) appropriate to the application. Applications may define an aperture appropriate to the smallest X dimension to be encountered or a variable aperture related to X dimension of the symbol. When the measuring aperture diameter is not specified in the application specification, Table 1 should be used as a guide. In the absence of a defined X dimension, the Z dimension shall be substituted.

NOTE 1 The choice of aperture size is very important for symbol grades to be measured consistently. The size of the measuring aperture affects whether voids in the symbol is “filled in” during the verification process. Therefore, the measuring aperture that is selected with reference to the range of nominal module size and the expected scanning environment will lead to measurements that are appropriate for the application. An aperture that is too small will not fill in unintentional voids that would lead to low grades or undecodable symbols. On the other hand, a measuring aperture that is too large blurs individual modules that are narrow relative to the aperture diameter, resulting in low modulation, and sometimes can prevent the symbols with small element widths from being decoded.

NOTE 2 A practical instrument is subject to manufacturing tolerances and optical affects that affects the actual effective measuring aperture diameter which results in deviations in measurements. The measurement tolerances are specified in ISO/IEC 15426-1.

Depending upon the specified aperture size and the dimensions of the actual elements within a symbol, the width of some of the narrow elements can be smaller than the measuring aperture diameter.

Table 1 — Guideline for diameter of measuring aperture

X **dimension** mm	**Aperture diameter** mm	**Reference number**
0,100 ≤ X < 0,180	0,075	03
0,180 ≤ X < 0,330	0,125	05
0,330 ≤ X < 0,635	0,250	10
0,635 ≤ X	0,500	20
NOTE The aperture reference number is the measuring aperture diameter divided by 25,0 µm, which approximates to the measuring aperture diameter in thousandths of an inch.		

NOTE 3 The measuring aperture is not to be confused with the opening (F-number) of a lens.

5.2.4 Optical geometry

The reference optical geometry for reflectivity measurements shall consist of:

a) a source of incident illumination which is uniform across the sample area at 45° from a perpendicular to the surface, and in a plane containing the illumination source that shall be both perpendicular to the surface and parallel to the bars;

b) a light collection device, the axis of which is perpendicular to the surface.

The light reflected from a circular sample area of the surface shall be collected within a cone; the angle at the vertex of which is 15°, centred on the perpendicular to the surface, through a circular measuring aperture, the diameter of which at 1:1 magnification shall be equivalent to that of the sample area.

NOTE Figure 1 illustrates the principle of the optical arrangement but is not intended to represent an actual device.

This reference geometry is intended to minimize the effects of specular reflection and to maximize those of diffuse reflection from the symbol. It is intended to provide a reference basis to assist the consistency of measurement. The actual optical geometry of individual scanning systems does not always correspond exactly to this reference geometry. Alternative optical geometries and components may be used, provided that their performance can be correlated with that of the reference optical arrangement defined in this subclause.

It is common for an application to use both linear and two-dimensional symbols. Optical setups used for 2D symbol quality assessment typically employ lights from four sides at 45°. Application specifications may consider specifying the reference optical geometry from ISO/IEC 15415, which consists of four rather than one light at 45° and denoted by the lighting specifier "/45Q" as the default, if verifiers that are also used for quality assessment of two-dimensional symbols are preferred to be used in the application.

NOTE For application specifications employing the lighting specifier "/45Q" as the default, refer to the optical geometry defined ISO/IEC 15415.