INTERNATIONAL STANDARD

ISO/IEC 15416

First edition
2000-08-15

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

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

Reference number
ISO/IEC 15416:2000(E)

© ISO/IEC 2000

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS

Not for Resale

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO/IEC 2000

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS

© ISO/IEC 2000 – All rights reserved

Not for Resale

Contents

Page

Foreword vi

Introduction vii

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Symbols and abbreviated terms 3
4.1 Abbreviations 3
4.2 Symbols 3

5 Measurement methodology 4
5.1 General requirements 4
5.2 Reference reflectivity measurements 5
5.2.1 Measurement wavelength(s) 5
5.2.2 Measuring aperture 5
5.2.3 Optical geometry 6
5.2.4 Inspection band 7
5.2.5 Number of scans 7
5.3 Scan reflectance profile 7
5.4 Scan reflectance profile assessment parameters 8
5.4.1 Element determination 9
5.4.2 Edge determination 9
5.4.3 Decode 10
5.4.4 Symbol contrast (SC) 10
5.4.5 Minimum reflectance (R_{min}) 10
5.4.6 Edge contrast (EC) 10
5.4.7 Modulation (MOD) 10
5.4.8 Defects 10
5.4.9 Decodability 10
5.4.10 Quiet zone check 11

6 Symbol grading 12
6.1 Scan reflectance profile grading 12
6.1.1 Decode 12
6.1.2 Reflectance parameter grading 12
6.1.3 Decodability 13
6.2 Expression of symbol grade 13

7 Substrate characteristics 13

Annex A (normative) **Decodability** 14
A.1 Two-width symbologies 14
A.2 Edge to similar edge decodable symbologies ((n, k) symbologies) 14

Annex B (normative) **Example of symbol quality grading** 16
B.1 Individual scan reflectance profile grading 16
B.2 Overall symbol grade 17

Annex C (informative) **Symbol grading flowchart** 18

Annex D (informative) **Substrate characteristics** 19
D.1 Substrate opacity 19
D.2 Gloss 19
D.3 Over-laminate 19

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

D.4 Static reflectance measurements 19
D.4.1 Prediction of Symbol Contrast (SC) 20
D.4.2 Prediction of Minimum Edge Contrast (EC_{min}) and Modulation (MOD) 20
D.4.3 Acceptability of measured and derived values 22

Annex E (informative) **Interpretation of the scan reflectance profile and profile grades** 23
E.1 Significance of scan reflectance profiles 23
E.2 Interpretation of results 23
E.3 Matching grades to applications 24
E.4 Alphabetic grading 25

Annex F (informative) **Guidance on selection of light wavelength** 26
F.1 Light sources 26
F.2 Effect of variations in wavelength 27

Annex G (informative) **Guidance on number of scans per symbol** 28

Annex H (informative) **Example of verification report** 29

Annex I (informative) **Comparison with traditional methodologies** 30
I.1 Traditional methodologies 30
I.2 Correlation of Print Contrast Signal with symbol contrast measurements 30
I.3 Guidance on grading for applications also specifying PCS 31

Annex J (informative) **Process control requirements** 32
J.1 Process control for repetitive printing 32
J.2 Number of scans 32
J.3 Bar width deviation 33
J.3.1 Two-width symbologies 33
J.3.2 (n, k) symbologies 33
J.3.3 Average bar width gain/loss 33

Bibliography 34

--`,,```,,,,````-`-`,,`,,`,`,,`---
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale
© ISO/IEC 2000 – All rights reserved

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 15416 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

Annexes A and B form a normative part of this International Standard. Annexes C to J are for information only.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

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 must be 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 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.

The performance of measuring equipment is the subject of a separate International Standard, ISO/IEC 15426.

This International Standard is intended to be substantially equivalent in technical content to EN 1635 and ANSI standards X3.182 - 1990 and ANSI/UCC5 on which it has been based. It should be read in conjunction with the symbology specification applicable to the bar code symbol being tested, which provides symbology-specific detail necessary for its application.

There are currently many methods of assessing bar code quality at different stages of symbol production. The methodology provided in this specification is not intended as a replacement for any current process control methods but gives essential additional quality information. This methodology provides a basis for grading the quality of bar code symbols in relation to their expected performance when read and therefore gives symbol producers and their trading partners a universally standardized means for communicating about the quality of bar code symbols after they have been printed. It also provides symbol producers with information enabling them to adjust their production process.

Alternative methods of quality assessment may be agreed between parties or as part of an application specification.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

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

1 Scope

This International Standard

— 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;

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

This International Standard 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 normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 7724-2:1984, *Paints and varnishes — Colorimetry — Part 2: Colour measurement.*

EN 1556:1998, *Bar coding — Terminology.*

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in EN 1556 and the following apply.

3.1
bar
A dark element corresponding to a region of a scan reflectance profile below the global threshold.

3.2
bar reflectance
The lowest reflectance value of an individual bar element in the scan reflectance profile of that element.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

3.3
decodability
The proportion of the available margin (between the ideal dimension of an element or combination of elements and the relevant reference threshold) that has not been consumed by the element or combination of elements, calculated for the element or combination of elements deviating most from its ideal dimension.

3.4
decode
Determination of the information encoded in a bar code symbol.

3.5
edge contrast
The difference between bar reflectance and space reflectance of two adjacent elements.

3.6
element reflectance non-uniformity
The reflectance difference between the highest peak and the lowest valley in the scan reflectance profile of an individual element or quiet zone.

3.7
global threshold
The reflectance level midway between the maximum and minimum reflectance values in a scan reflectance profile used for the initial identification of elements.

3.8
gloss
The propensity of a surface to reflect a proportion of incident light in a specular manner.

3.9
inspection band
The band (usually from 10 % to 90 % of the height of a bar code symbol) across which measurements are taken (see Figure 2).

3.10
measuring aperture
A circular opening which governs the effective sample area of the symbol, and the diameter of which at 1:1 magnification is equal to that of the sample area.

3.11
modulation
The ratio of minimum edge contrast to symbol contrast.

3.12
(n, k) symbology
A class of bar code symbologies in which each symbol character is n modules in width and is composed of k bar and space pairs.

3.13
peak
A point of higher reflectance in a scan reflectance profile with points of lower reflectance on either side.

3.14
sample area
The effective area of the symbol within the field of view of the measurement device.

3.15
scan reflectance profile
Plot of variations in reflectance with linear distance along a scan path.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

3.16
scan path
The line along which the centre of the sample area traverses the symbol, including quiet zones.

3.17
space
A light element corresponding to a region of a scan reflectance profile above the global threshold.

3.18
space reflectance
The highest reflectance value of an individual space element or quiet zone in the scan reflectance profile of that element or quiet zone.

3.19
two-width symbology
A bar code symbology in which symbol characters consist only of narrow and wide elements the widths of which are in a constant ratio to each other.

3.20
valley
A point of lower reflectance in a scan reflectance profile with points of higher reflectance on either side.

3.21
vertical redundancy
The property of a bar code symbol whereby there exist multiple possible scan paths as a result of the symbol being significantly higher than the height of a single scan line.

4 Symbols and abbreviated terms

4.1 Abbreviations

EC: Edge contrast

EC_{min}: Minimum value of EC

ERN: Element reflectance non-uniformity

ERN_{max}: Maximum value of ERN

GT: Global threshold

MOD: Modulation

PCS: Print contrast signal

RT: Reference threshold

SC: Symbol contrast

SRD: Static reflectance difference

4.2 Symbols

A: Average achieved width of element or element combinations of a particular type

e: Width of widest narrow element

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

E: Width of narrowest wide element

$\mathbf{e_i}$: i^{th} edge to similar edge measurement, counting from leading edge of symbol character

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

$\mathbf{R_b}$: Bar reflectance

$\mathbf{R_D}$: Dark reflectance

$\mathbf{R_L}$: Light reflectance

$\mathbf{R_S}$: Space reflectance

$\mathbf{R_{max}}$: Maximum reflectance

$\mathbf{R_{min}}$: Minimum reflectance

$\mathbf{RT_j}$: Reference threshold between measurements j and (j+1) modules wide

S: Total width of a character

V: Decodability value

$\mathbf{V_C}$: Decodability value for a symbol character

X: Nominal narrow element dimension

Z: Average achieved narrow element dimension

5 Measurement methodology

5.1 General requirements

The measurement methodology defined in this standard 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 single light wavelength and a measurement aperture of a diameter defined by the application specification or determined in accordance with 5.2.1 and 5.2.2.

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.

The sampling method should be based on a statistically valid sample size within the lot or batch being tested. A minimum grade for acceptability shall be established prior to quality control inspection. In the absence of a

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

sampling plan defined in formal quality assurance procedures or by bilateral agreement, a suitable plan may be based on the recommendations in ISO 2859 or ISO 3951.

5.2 Reference reflectivity measurements

Equipment for assessing the quality of bar code symbols in accordance with this standard 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 5.2.4.

The measured reflectance values shall be expressed in percentage terms either with reference to the reflectance of a barium sulphate or magnesium oxide reference sample complying with the requirements of ISO 7724, which shall be taken as 100 %, or by means of calibration and reference to recognised national standards laboratories for samples illuminated at 45° with the diffusely reflected light being collected perpendicular to the surface.

5.2.1 Measurement wavelength(s)

The peak light wavelength used for measurements should be specified in the application specification to suit the intended scanning environment. When the wavelength is not specified in the application specification, measurements should be made using the wavelength of light that approximates most closely to the wavelength expected to be used in the scanning process. Refer to annex F for guidance on the selection of the wavelength of light.

5.2.2 Measuring aperture

The nominal diameter of the measuring aperture should be specified by the user application specification, to suit the intended scanning environment. When the measuring aperture diameter is not specified in the application specification, Table 1 should be used as a guide. In an application where a range of X dimensions will be encountered, all measurements shall be made with the aperture appropriate to the smallest X dimension to be encountered.

In the absence of a defined X dimension, the Z dimension shall be substituted.

The effective measuring aperture diameter may vary slightly from its nominal dimension due to manufacturing tolerances and optical effects. Note that the measured width of some of the narrow elements may 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 approximates to the measuring aperture diameter in thousandths of an inch; this reference number is used for consistency with the ANSI standard X3.182.		

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

5.2.3 Optical geometry

The reference optical geometry for reflectivity measurements shall consist of:

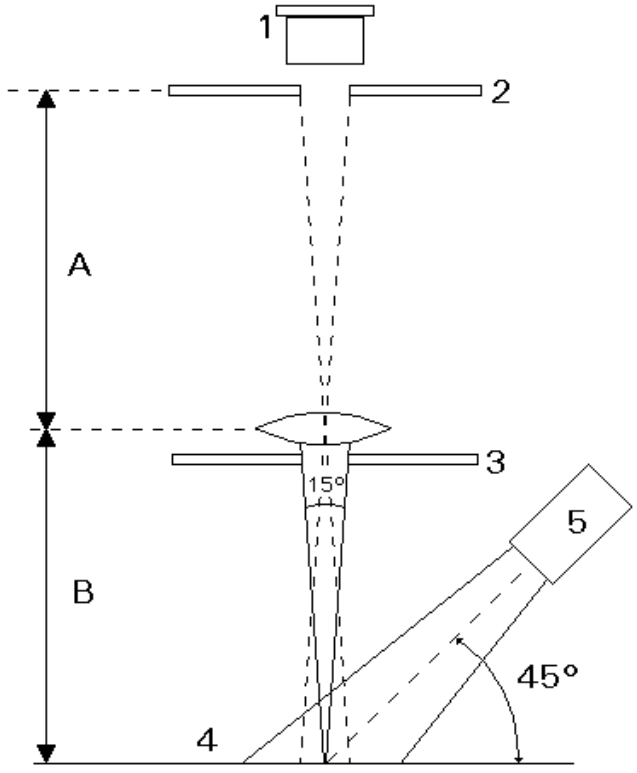
a) a source of incident illumination which is uniform across the sample area at 45° from a perpendicular to the surface, and in a plane containing the illumination source that shall be both perpendicular to the surface and parallel to the bars, and

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 minimise the effects of specular reflection and to maximise those of diffuse reflection from the symbol. It is intended to provide a reference basis to assist the consistency of measurement. It may not correspond with the optical geometry of individual scanning systems. 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 section.



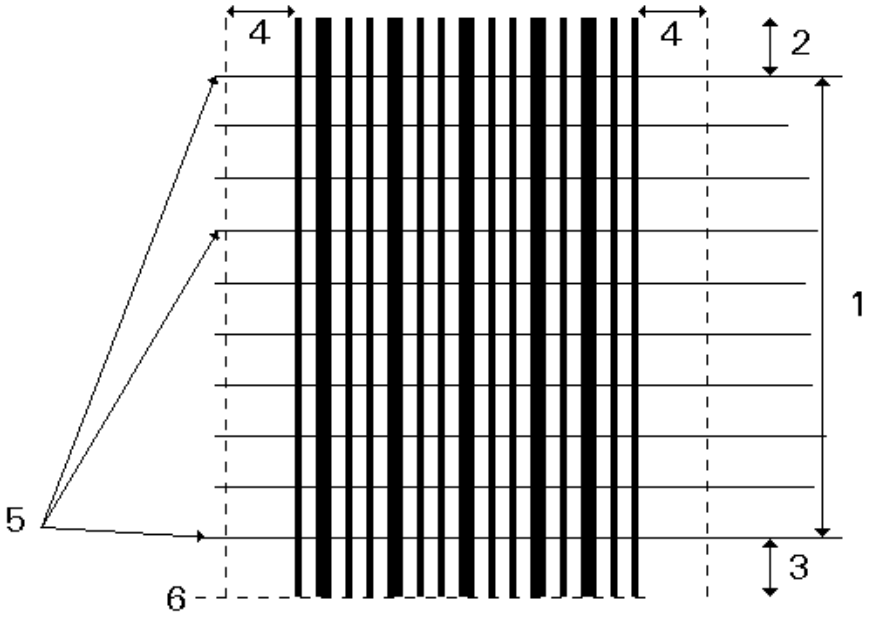
1 - Light sensing element
2 - Aperture at 1:1 magnification (measurement A = measurement B)
3 - Baffle
4 - Sample
5 - Light source

Figure 1 — Reference optical arrangement

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

5.2.4 Inspection band

The area within which all measurement scan paths shall lie shall be contained between two lines perpendicular to the height of the bars of the symbol, as illustrated in Figure 2. The lower line shall be positioned at a distance above the average lower edge of the bar pattern of the symbol, and the upper line at the same distance below the average upper edge of the bar pattern of the symbol. This distance shall be equal to 10 % of the average bar height, or the measuring aperture diameter, whichever is greater. The inspection band shall extend to the full width of the symbol including quiet zones.



1 - Inspection band (normally 80 % of average bar height)
2 - 10 % of average bar height, or aperture diameter if greater, above inspection band
3 - 10 % of average bar height, or aperture diameter if greater, above average bar bottom edge
4 - Quiet zones
5 - Scanning lines
6 - Average bar bottom edge

Figure 2 — Inspection band

5.2.5 Number of scans

In order to provide for the effects of variations in symbol characteristics at different positions in the height of the bars, a number of scans shall be performed across the full width of the symbol including both quiet zones with the appropriate measuring aperture and a light source of defined nominal wavelength. These scans shall be approximately equally spaced through the height of the inspection band. The minimum number of scans per symbol should normally be ten, or the height of the inspection band divided by the measuring aperture diameter, whichever is lower. Refer to annex G for guidance on the number of scans.

The overall quality grade of the symbol is determined by averaging the quality grades of the individual scans, in accordance with clause 6.

5.3 Scan reflectance profile

Bar code symbol quality assessment shall be based on an analysis of the scan reflectance profiles. The scan reflectance profile is a plot of reflectance against linear distance across the symbol. If scanning speed is not constant, measuring devices plotting reflectance against time should make provision to compensate for the effects

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

of acceleration or deceleration. If the plot is not a continuous analogue profile, the measurement intervals should be sufficiently small to ensure that no significant detail is lost and that dimensional accuracy is adequate.

Figure 3 is a graphical representation of a scan reflectance profile. The vertical axis represents reflectance and the horizontal axis linear position. The high-reflectance areas are spaces and the low-reflectance areas are bars. The high-reflectance areas on the extreme left and right are the quiet zones. The important features of the scan reflectance profile can be determined by manual graphical analysis or automatically by numerical analysis. For example, the highest reflectance point on the scan reflectance profile in Figure 3 is approximately 82 % and the lowest is approximately 10 %.

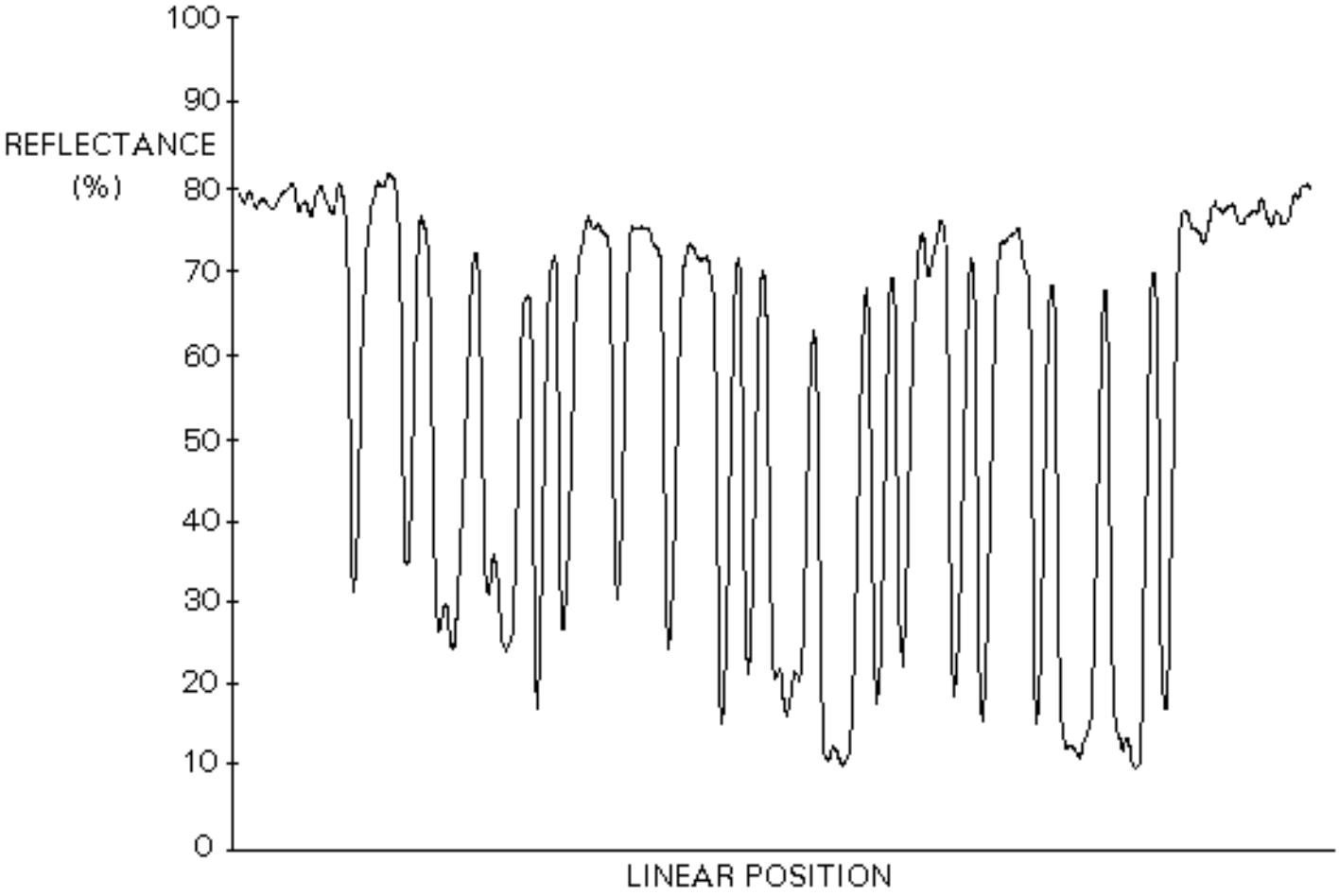


Figure 3 — Scan reflectance profile

5.4 Scan reflectance profile assessment parameters

The scan reflectance profile parameters described in 5.4.1 to 5.4.9 shall be assessed for compliance with this standard. Figure 4 is the same scan reflectance profile as Figure 3 with certain features indicated.

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale
© ISO/IEC 2000 – All rights reserved

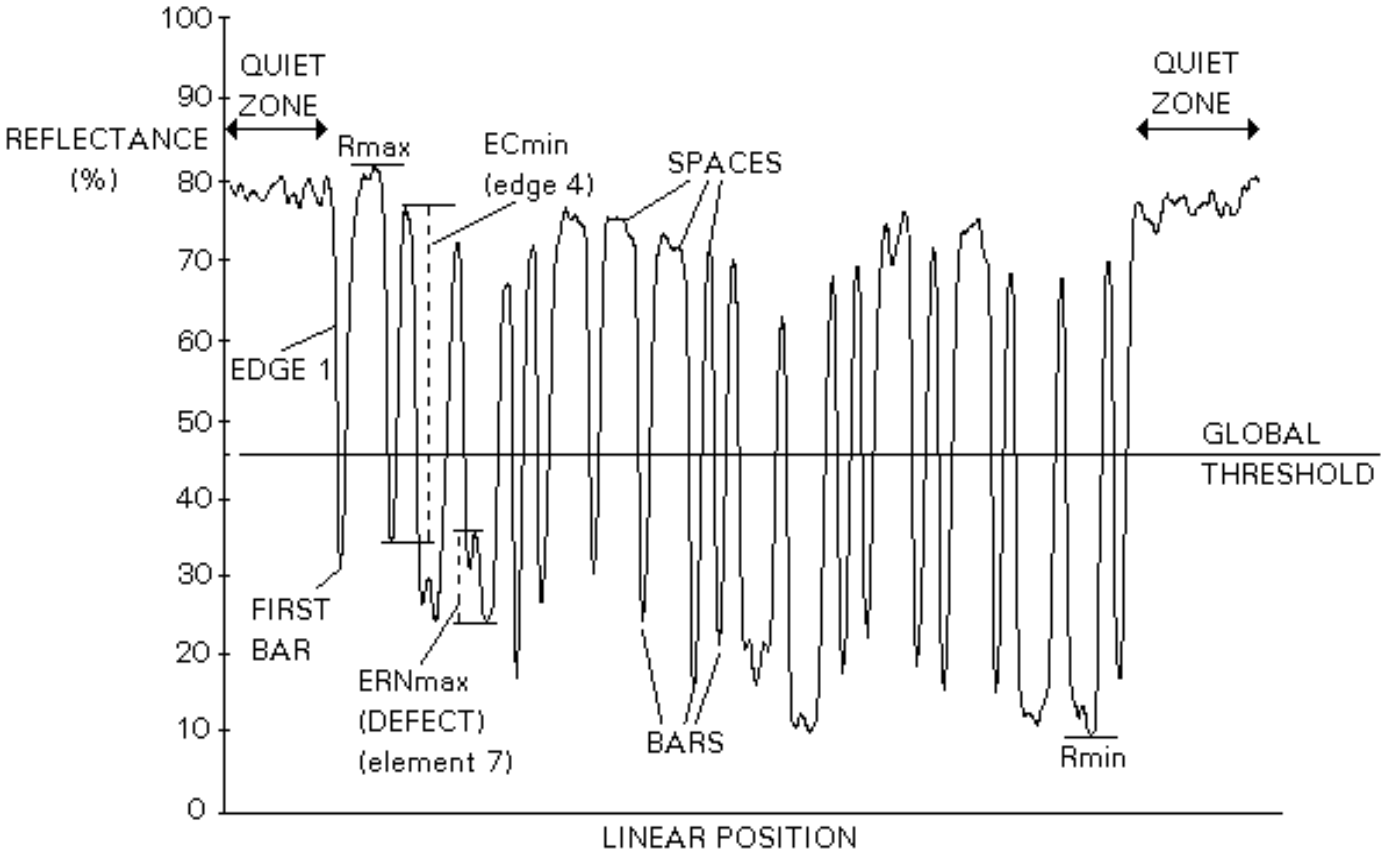


Figure 4 — Features of scan reflectance profile

5.4.1 Element determination

To locate the bars and spaces, a global threshold shall be established. The global threshold shall be the reflectance value midway between the highest and lowest reflectance values measured in the scan reflectance profile, or:

$$GT = (R_{max} + R_{min})/2$$

where: R_{max} represents the highest reflectance value

R_{min} represents the lowest reflectance value

Each region above the global threshold shall be regarded as a space and the highest reflectance value in the region shall be designated the space reflectance, R_s. Similarly, the region below the global threshold shall be regarded as a bar, and the lowest reflectance in the region shall be designated the bar reflectance, R_b.

5.4.2 Edge determination

An element edge shall be defined as being located at the point where the scan reflectance profile intersects the mid-point between R_s and R_b of two adjacent regions, i.e. where the reflectance value is $(R_s + R_b)/2$. If more than one point satisfying this definition exists between adjoining elements, then the edge position and the element widths will be ambiguous and the scan reflectance profile will fail to decode in accordance with 5.4.3. The quiet zones and intercharacter gaps, if any, are considered to be spaces.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

5.4.3 Decode

The symbology reference decode algorithm shall be used to decode the symbol using the element edges determined in 5.4.2. This algorithm may be found in the symbology specification.

5.4.4 Symbol contrast (SC)

Symbol contrast is the difference between the highest and lowest reflectance values in a scan reflectance profile.

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

5.4.5 Minimum reflectance (R_{min})

Rmin is the lowest reflectance value in the scan reflectance profile. R_{min} shall not be higher than $0{,}5R_{max}$. This parameter is intended to ensure that R_{min} shall not be too high, and to ensure an adequate margin between background and bar reflectances, especially when the value of R_{max} is high.

5.4.6 Edge contrast (EC)

Edge contrast is the difference between the R_s and R_b of adjoining elements including quiet zones. The lowest value of edge contrast found in the scan reflectance profile is the minimum edge contrast, EC_{min}.

$$EC = R_s - R_b$$

5.4.7 Modulation (MOD)

Modulation is the ratio of the minimum edge contrast to symbol contrast.

$$MOD = EC_{min} / SC$$

5.4.8 Defects

Defects are irregularities found within elements and quiet zones, and are measured in terms of element reflectance non-uniformity.

Element reflectance non-uniformity within an individual element or quiet zone is the difference between the reflectance of the highest peak and the reflectance of the lowest valley. When an element consists of a single peak or valley, its reflectance non-uniformity is zero. The highest value of element reflectance non-uniformity found in the scan reflectance profile is the maximum element reflectance non-uniformity. Defect measurement is expressed as the ratio of the maximum element reflectance non-uniformity (ERN_{max}) to symbol contrast.

$$Defects = ERN_{max} / SC$$

5.4.9 Decodability

The decodability of a bar code symbol is a measure of the accuracy of its production in relation to the appropriate reference decode algorithm. Bar code scanning equipment can generally be expected to perform better on symbols with higher levels of decodability than on those with lower decodability.

Rules governing the nominal dimensions for each bar code symbology are given in particular symbology specifications. The reference decode algorithm allows reasonable margin for errors in the printing and reading processes by defining one or more reference thresholds at which a decision is made as to the widths of elements or other measurements.

The decodability of a scan reflectance profile is the fraction of available margin which has not been consumed by the printing process and is thus available for the scanning process. When calculating the decodability value V for a scan reflectance profile, regard shall be had to the measurements required by the reference decode algorithm in

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

the relevant symbology specification. In the following paragraph the term "measurement" shall be taken to refer either to a single element width, in symbologies which use these directly in the reference decode algorithm (e.g. "Code 39"), or to the combined width of two or more adjacent elements, in symbologies using edge to similar edge measurements for decoding (e.g. "Code 128").

The decodability value is calculated with reference to:

a) the average achieved width (referred to in the formula below as A) for measurements of a particular type (e.g. narrow elements, or bar + space combinations nominally totalling 2 (or 3, or 4 ...) modules) in the scan reflectance profile;

b) the reference threshold applicable to measurements of the same type as A (referred to in the formula below as RT);

c) the actual measurement showing the greatest deviation from A in the direction of the reference threshold, (referred to in the formula below as M).

The general form of the formula for calculating V is as follows:

V = absolute value of ((RT - M) / (RT - A)).

where: (RT - M) represents the remaining margin not used by printing variation,

(RT - A) represents the total theoretical margin based on the ideal measurement of the element(s).

Figure 5 illustrates this principle. The shaded area represents the range within which measurements of the same type as A (e.g. narrow elements) fall. All measurements are taken from 0.

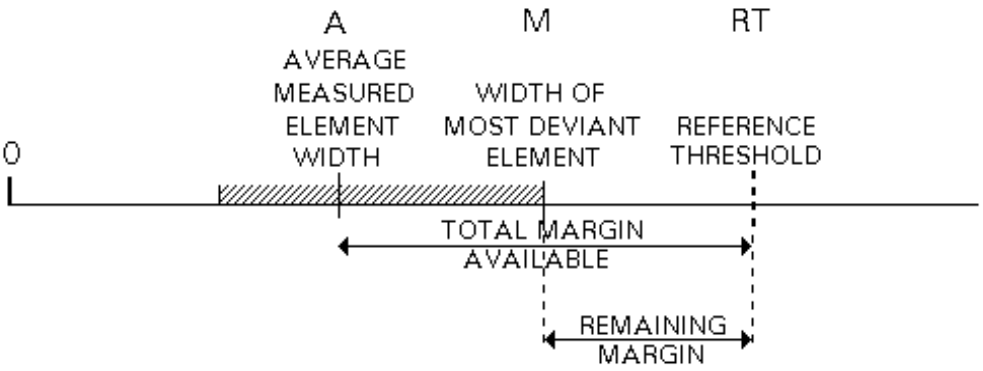


Figure 5 — Principle of decodability measurement

More specific formulae applicable to either two-width symbologies or (n, k) symbologies are defined in annex A. Reference should also be made to the symbology specification for the particular computation of decodability unique to each symbology.

NOTE Depending on the symbology and its reference decode algorithm, the decodability measurement may or may not be indicative of bar width gain or loss, but does not provide sufficient information on this for process control. Consequently, for purposes of symbol production process control, measurement of bar width gain or loss should also be performed (see annex J), although this measurement does not enter into the symbol grading process.

5.4.10 Quiet zone check

The average narrow element width, Z, shall be calculated and revised quiet zones determined based on this dimension. R_{max}, ERN of the quiet zones, and R_s of the quiet zones, as used in the initial scan reflectance profile analysis, shall be compared with new values obtained for the revised quiet zones. If the value(s) differ, then affected portions of the scan reflectance profile analysis shall be repeated.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

6 Symbol grading

As a consequence of the use of different types of bar code reading equipment under differing conditions in actual applications, the level of quality required of a bar code symbol to ensure an acceptable level of performance will differ. Application specifications should therefore define the required performance in terms of symbol grade in accordance with this standard, following the guidelines in E.3.

Symbol grading shall be used to derive a relative measure of symbol quality under the measurement conditions used. Each scan reflectance profile shall be analysed and a grade on a descending scale of integers from 4 to 0 shall be allocated to each of the parameters evaluated. The grade 4 represents the highest quality, while the grade 0 represents failure. The scan reflectance profile grade for each scan reflectance profile shall be the lowest grade of any parameter in that scan reflectance profile. The overall symbol grade shall be the arithmetic mean of the scan reflectance profile grades. If any two scans of the same symbol yield different decoded data, then the overall symbol grade, irrespective of individual scan reflectance profile grades, shall be 0.

In order to determine the causes of poor quality grades, it is necessary to examine the grades for each parameter in the scan reflectance profile in question as described in E.2. For process control purposes the average of the grades or the values for certain parameters obtained from all the scan reflectance profiles may prove informative. The parameters most likely to be of use are symbol contrast, decodability and modulation (grades or values) and bar width gain or loss (value). If the grades alone do not provide sufficient explanation it may also be necessary to examine the plot(s) of the scan reflectance profile(s).

6.1 Scan reflectance profile grading

The scan reflectance profile grade shall be the lowest grade of the following:

a) decode;

b) symbol contrast (SC);

c) minimum reflectance (R_{min});

d) minimum edge contrast (EC_{min});

e) modulation (MOD);

f) defects;

g) decodability (V);

h) any additional requirements imposed by the application or symbology specification.

It is appropriate to measure these parameters in the sequence given above.

6.1.1 Decode

Decodable symbols shall comply with the symbology specification, notably in respect of character encodation, start and stop patterns, symbol check character(s), quiet zones and intercharacter gaps (where applicable). If the scan reflectance profile cannot be decoded using the symbology reference decode algorithm, then it shall receive the failing grade 0. Otherwise, it shall receive the grade 4. Analysis of the scan reflectance profile will normally indicate the reason for a failure to decode.

6.1.2 Reflectance parameter grading

Depending on their values, symbol contrast, modulation and defects may be graded from 4 to 0; minimum reflectance and minimum edge contrast grades may be graded either 4 or 0. These parameters are interdependent and need to be considered together.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Table 2 defines the parameter values corresponding to the various grades.

Table 2 — Reflectance parameter grading

Grade	R_{min}	SC	EC_{min}	MOD	Defects
4	$\leq 0{,}5R_{max}$	≥70 %	≥15 %	≥0,70	≤0,15
3		≥55 %		≥0,60	≤0,20
2		≥40 %		≥0,50	≤0,25
1		≥20 %		≥0,40	≤0,30
0	$>0{,}5R_{max}$	<20 %	<15 %	<0,40	>0,30

6.1.3 Decodability

The decodability value, V, for each scan reflectance profile shall be calculated according to the formula for the type of symbology in question set out in annex A, supplemented where necessary by formulae specific to the symbology in question, contained in the symbology specification. Decodability is graded from 4 to 0 according to Table 3.

Table 3 — Decodability grades

V	Grade
≥0,62	4
≥0,50	3
≥0,37	2
≥0,25	1
<0,25	0

6.2 Expression of symbol grade

A symbol grade is only meaningful if it is expressed in conjunction with the measurement wavelength and aperture used. It should be shown in the format G/A/W, where G is the overall symbol grade, i.e. the arithmetic mean of the scan reflectance profile grades to one decimal place, A is the aperture reference number, from Table 1, and W is the light wavelength in nanometres.

For example, 2,7/05/660 would indicate that the average of the grades of the scan reflectance profiles was 2,7 when these scan reflectance profiles were obtained with the use of a 0,125 mm aperture (ref. no. 05) and a 660 nm light source.

7 Substrate characteristics

Certain characteristics of the substrate, notably gloss, low opacity and the presence of an over-laminate may affect reflectance measurements, and the recommendations in annex D should be taken into account if any of these factors is present.

--`,,```,,,,````-`-`,,`,,`,`,,`---

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex A
(normative)

Decodability

This annex defines general formulae for the calculation of the decodability value V for symbologies for which the reference decode algorithm defines reference thresholds. These formulae may be supplemented by additional formulae specific to an individual symbology and defined in the relevant symbology specification.

A.1 Two-width symbologies

In each scan reflectance profile, calculate Z and N for the whole symbol.

The achieved wide:narrow ratio N for the symbol shall be calculated as follows:

N = (Average wide bar + average wide space) / 2Z

and the Z dimension shall be calculated as follows:

Z = (Average narrow bar + average narrow space) / 2

Intercharacter gaps shall not be included in these calculations.

For each symbol character or auxiliary pattern, calculate RT in accordance with the reference decode algorithm.

Then V1 = (RT - e) / (RT - Z)

V2 = (E - RT) / ((N $\times$ Z) - RT)

V_C = the lesser of V1 or V2

The decodability value V for the scan reflectance profile shall be the lowest value of V_C for any symbol character or auxiliary pattern.

A.2 Edge to similar edge decodable symbologies ((n, k) symbologies)

If necessary, in each scan reflectance profile, calculate Z for the whole symbol:

Z = (average S) / n

where S and n are as defined in 4.2.

For each symbol character, determine a set of reference thresholds RT_j:

for all j = 1 to n - 2(k - 1)

RT_j = ((j + 0,5) $\times$ S) / n

where S, n and k are as defined in 4.2.

for all i = 1 to 2(k - 1) and all j = 1 to n - 2(k - 1)

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

let K = smaller of absolute value of (e_i - RT_j) or previous K

where e_i = measurement from leading edge of element i to leading edge of element (i + 2).

Then $V_C = K / (S / 2n)$.

The decodability value V for the scan reflectance profile shall be the lowest value of V_C for any symbol character or auxiliary pattern.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex B
(normative)

Example of symbol quality grading

B.1 Individual scan reflectance profile grading

This annex illustrates the determination of the grades for the scan reflectance profile shown in Figure 3, assuming measurement using a 900 nm (infra-red) light source and a 0,125 mm aperture:

Referring to Figure 3, the actual reflectance values may be determined graphically in order to grade the scan reflectance profile.

Minimum reflectance (R_{min}) is 10 % and the maximum reflectance (R_{max}) is 82 %. The global threshold is therefore 46 %. R_{min} satisfies the ($0,5 \times R_{max}$) test by being less than ($0,5 \times 82$ %) = 41 %.

Symbol contrast (SC) is 82 - 10 = 72.

Minimum edge contrast (EC_{min}) occurs on edge 4, where R_s and R_b are 76 % and 34 % respectively. EC_{min} is 76 - 34 = 42.

Modulation (MOD) is therefore 42 / 72 = 0,58

Maximum element reflectance non-uniformity (ERN_{max}), the largest non-uniformity or defect in a scan reflectance profile, can be found as the result of a void in element 7, a bar. ERN_{max} is equal to 36 - 24 = 12. Note that the ERN_{max} can be in any bar, space or quiet zone. The Defects value therefore is

12 / 72 = 0,17.

Assuming that the symbol has decoded correctly (as characters "Start $ M Stop" in "Code 39") and that the decodability value V has been calculated as 0,58, the following individual parameter grades and the scan reflectance profile grade can be determined for the scan reflectance profile in Figure 3.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Table B.1 — Grades for the scan reflectance profile as shown in Figure 3

Parameter	Value	Grade
Decode		4
R_{max}	82 %	
R_{min}	10 %	4
SC	82 - 10 = 72 %	4
EC_{min}	76 - 34 = 42 %	4
MOD	42 / 72 = 0,58	2
Defects	12 / 72 = 0,17	3
Decodability	0,58	3

Since the lowest individual grade, in this instance the grade for MOD, is 2, the scan reflectance profile grade is also 2.

See also annex H.

B.2 Overall symbol grade

Assuming that a series of ten scans of the symbol used in Figure 3 gave the following scan reflectance profile grades:

2, 2, 3, 3, 4, 2, 2, 2, 3, 3

the arithmetic mean of these grades, and hence the overall symbol grade, is 2,6. The result should be reported in the form

2,6/05/900

For information, this result would be shown, using alphabetic grading according to ANSI X3.182 as:

B/05/900

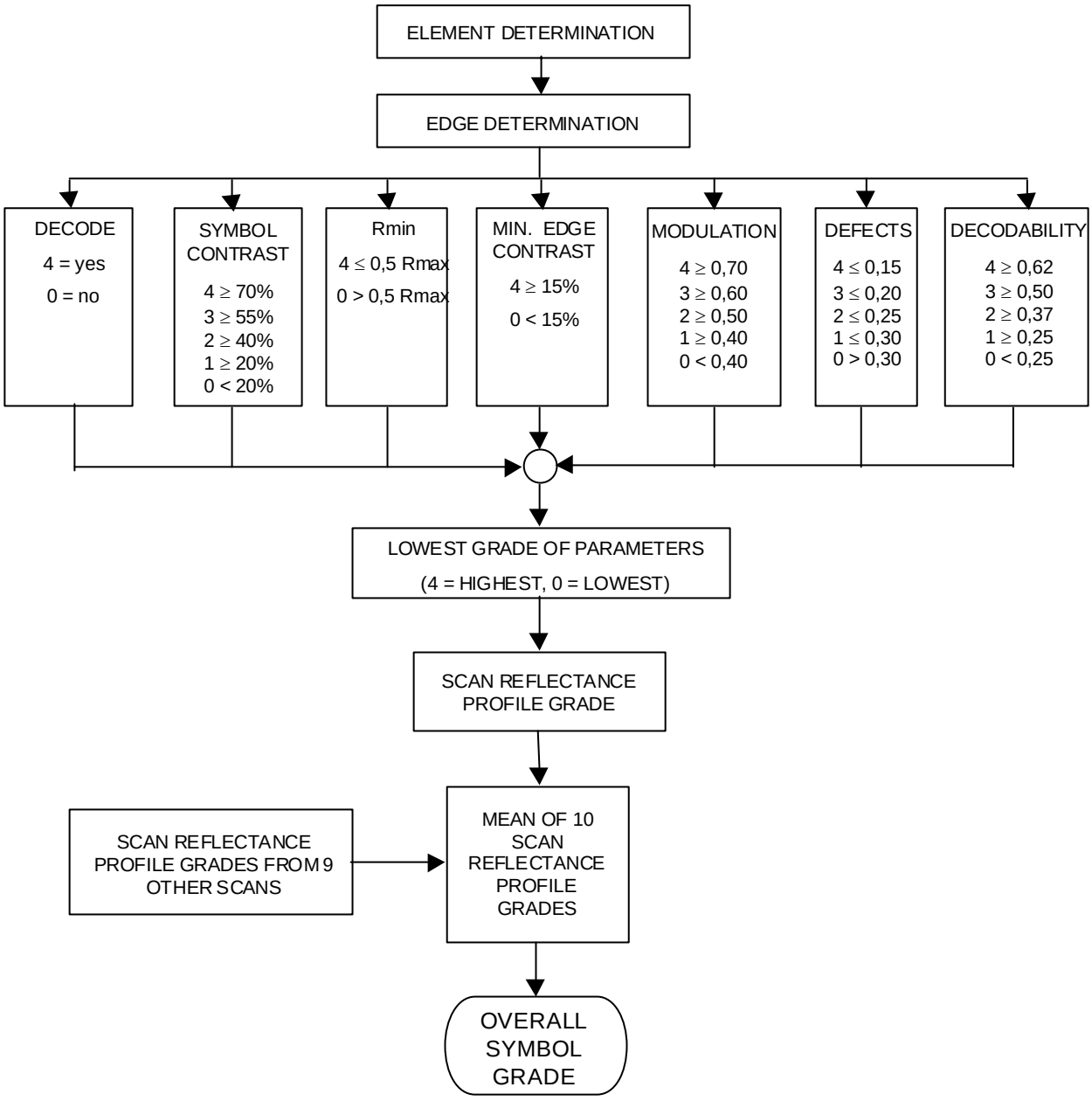
© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex C
(informative)

Symbol grading flowchart

The flowchart below illustrates the steps in the symbol grading process, once the scan reflectance profile has been obtained. Parameters are measured in accordance with subclauses 5.4.1 to 5.4.10 and graded in accordance with 6.1.



--`,,```,,,,````-`-`,,`,,`,`,,`---

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex D
(informative)

Substrate characteristics

In certain circumstances for example, the design and production of printed packaging materials incorporating bar code symbols, it is necessary or desirable to assess the acceptability of substrates and/or ink colours for a given bar code application, before a bar code symbol is available which could be tested in accordance with this International Standard.

D.1 Substrate opacity

The symbol shall be graded according to the reflectance parameters in 6.1.2 when measured in its final configuration, e.g. final filled package.

If it is not possible to measure the symbol in this configuration then the effects of show-through of high-contrast interfering patterns may be ignored if when measured as follows the substrate opacity is 0,85 or greater. If the opacity is less than 0,85 the symbol should be measured when backed by a uniform dark surface the reflectance of which is not more than 5 %.

The opacity of the substrate shall be calculated as follows:

Opacity = R2 / R1

where: R1 = Reflectance of a sample sheet of the substrate backed with a white surface the reflectance of which is 89 % or greater.

R2 = Reflectance of the same sample sheet backed with a black surface of not more than 5 % reflectance.

D.2 Gloss

The reference illumination conditions specified for the measurement of reflectance should enable the maximum rejection of specular reflection while giving a representative assessment of the diffuse reflectance of the symbol and substrate. Highly glossy materials and those whose diffuse reflectance characteristics vary with the angle of incident and/or collected light may yield grades differing from those obtained by the use of the reference optical arrangement.

D.3 Over-laminate

A symbol intended to be covered with a protective lamination should be graded according to the reflectance parameters in 6.1.2 when measured with the laminate in place. The thickness of the laminate including its adhesive should be as small as possible in order to minimise its effects on the reading performance of the symbol.

D.4 Static reflectance measurements

In some cases it may be desirable to carry out static reflectance measurements of samples of the substrate on which a bar code is to be printed and on colour patches or ink samples which replicate the colour in which the bar code will be printed. The following guidelines provide a means which, if it is followed, will predict as closely as is generally possible the results which will be obtained when the symbol is scanned dynamically.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Static reflectance measurements should be made with the wavelength of light, aperture size and optical arrangement which relate to the application and which are specified in accordance with 5.2.1, 5.2.2 and 5.2.3 of this International Standard.

Where reflectance measurement equipment meeting the requirements of this annex is not available, optical density measurements may be made using a standard densitometer with an appropriate light source and converted to reflectance values; density (D) and reflectance (R) are related as follows:

$$R = 100 / 10^{D}$$

NOTE It is impossible to predict to a high degree of accuracy the symbol contrast and, in particular, the edge contrast which will be achieved in the printed symbol. It is therefore appropriate to allow some safety margin above the minimum values for specified grades.

D.4.1 Prediction of Symbol Contrast (SC)

The prediction of SC requires that measurements of reflectance be made on samples which simulate the highest (R_{max}) and lowest reflectance (R_{min}) areas which will be present in the finished symbol.

It is probable that in most bar code symbols R_{max} will be found in the quiet zone of the symbol; therefore to simulate the conditions found in the quiet zone, R_{max} should be measured in the centre of a sample area, at least 10X in diameter, of the material on which the symbol is to be printed.

It is probable that in most bar code symbols R_{min} will be found in the widest bars of the symbol; therefore to simulate the conditions most likely to yield a value of R_{min} consistent with that which would be found in practice, reflectance should be measured in the centre of a strip of material 2X to 3X wide and which matches the colour in which the bars are to be printed.

A predicted value of SC can then be calculated:

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

D.4.2 Prediction of Minimum Edge Contrast (EC_{min}) and Modulation (MOD)

In order to assess the grade for modulation (MOD), it is necessary to predict the minimum value of Edge Contrast likely to be found in practice. It is best to make measurements of edge contrast on the printed symbol. If that is not possible, the prediction of EC_{min} requires that measurements of reflectance be made on samples which simulate the smallest reflectance difference which will be found between adjacent elements. It is probable that in most bar code symbols this condition will be found where a light and a dark element which are each 1X in width are adjacent to each other and where the element on the other side of the light element is a wide dark element.

To simulate this condition a sample of material, which is of the colour in which the bar code symbol will be printed, should be cut to form a mask of the type shown in Figure D.1.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale



Figure D.1 — Mask for static reflectance measurements

The mask shown in Figure D.1 should be made of a material that is as thin as is practical. It will however have some thickness and would therefore be capable of casting a shadow. To ensure that the effects of this are minimised, it is essential that the light source(s) of the instrument used to make the measurements are oriented to be in line with the long axis of the elements in which the measurements are being made. The narrow dark element AA and the narrow light element BB should each be equal in width to the X dimension of the symbol to be printed and the height of BB should be at least 20X or 10 mm, whichever is greater.

The measurement of the reflectance value R_s should be made in the narrow light element which is formed when the mask in Figure D.1 is placed over a background of the material and colour on which the bar code is to be printed.

The measurement of the reflectance value R_b should be made in the narrow dark element which is formed when the mask in Figure D.1 is placed over a background of the material and colour on which the bar code is to be printed.

A predicted value of Ec_{min} can then be calculated:

$$Ec_{min}' = R_s - R_b.$$

NOTE For materials which do not satisfy the tests for opacity, which are detailed in C.1, the measurements which are made for the purpose of predicting SC and EC_{min} should be made with the test samples backed by a uniform dark surface, the reflectance of which is not more than 5 %. The same measurements should then be made with the test samples backed by a uniform surface the reflectance of which is not less than 89 %. The calculated values of static SC and EC_{min} shall be equal to or greater than the minimum values for the grade selected for the application, for tests on both the dark and light backgrounds.

A predicted value of MOD can be calculated:

$$MOD' = Ec_{min}' / SC'$$

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

D.4.3 Acceptability of measured and derived values

The grades corresponding to the static values of SC and EC_{min} and to the derived value for Modulation (MOD) shall all be equal to or higher than the minimum overall symbol grade specified for the application.

For applications where Print Contrast Signal (PCS) is the preferred method of determining the reflectance characteristics of a bar code symbol, an approximation of the value of PCS can be determined from the values measured for the purpose of predicting SC. Refer to annex I.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex E
(informative)

Interpretation of the scan reflectance profile and profile grades

E.1 Significance of scan reflectance profiles

The scan reflectance profile represents the signal from a typical bar code scanning device. In a bar code reader, this signal is processed by an edge finding circuit prior to arriving at the decoder.

In order to allow a variety of edge finding circuits to find the intended elements, the following reflectance parameters should be considered:

— the global threshold shall be traversed by every edge in the symbol;

— symbol contrast, modulation, and minimum edge contrast should not be too low;

— defects and minimum reflectance should not be too high.

In addition, to allow a decoder to function, the following parameters should be considered:

— decode;

— decodability.

E.2 Interpretation of results

When examining a symbol with a view to drawing conclusions about the possible causes of low grades, individual parameter grades should be examined as well as the overall grade. There is a degree of interdependence between the parameters, but typical causes and effects are listed below. For process control purposes, in addition to the graded parameters, the measurement of the average bar width gain or loss may be used for monitoring the performance of a printer or printing press during an extended print run.

Bar width gain:

— may be reported directly (as average);

— reduces EC;

— reduces MOD;

— reduces decodability:

  — if not systematic, decodability will suffer though average bar width gain does not appear excessive;

  — if systematic, decodability will appear low and average bar width gain will be higher;

— may cause decode failure if excessive.

Bar width loss:

— may be reported directly (as average);

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

— increases EC initially; when excessive, reduces EC;

— increases MOD initially; when excessive, reduces MOD;

— may increase R_{min};

— reduces decodability:

  — if not systematic, decodability will suffer though average bar width loss does not appear excessive;

  — if systematic, decodability will appear low and average bar width loss will be higher;

— may cause decode failure if excessive.

Irregular element edges:

— cause variations in decodability between scan reflectance profiles;

— may cause decode failure if excessive.

Uneven inking:

— decreases EC;

— decreases MOD;

— may increase ERN_{max};

— may cause spurious elements to be detected (decode failure).

Voids and/or specks:

— increase ERN;

— if excessive in size may cause spurious elements to be detected (decode failure);

— may cause edge determination failure.

E.3 Matching grades to applications

Because of the varying features of bar code systems, notably:

— vertical redundancy,

— tolerances in decoding algorithms,

— ability of operators to rescan in the event of failure to read,

— availability of scanning equipment with multiple scan paths,

symbols with differing grades may give good performance in practice. Application specifications should specify the minimum acceptable grade (together with aperture size and light wavelength) to suit the characteristics of the scanning environment.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Symbols with an overall grade of 3,5 or better are the best quality and will in principle perform most reliably. This grade should be specified as a minimum where the reader crosses the symbol once only (with little possibility of rescanning in the event of failure to read) or is limited to a fixed single scan path.

A symbol graded between 2,5 and 3,5 if scanned in a single path may require rescanning to decode. A minimum grade of 2,5 is appropriate for systems where the symbol will be read on most occasions in a single scan pass but which allow for rescanning.

Symbols graded between 1,5 and 2,5 are more likely to require rescans than those with higher grades. For best read performance, devices which provide for multiple scan paths across the symbol should be used, or the system should be prepared to allow frequent rescan attempts.

Symbols with grades between 0,5 and 1,5 should be read by equipment providing for multiple, unique scan paths across the symbol. Some readers may fail to scan some such symbols successfully. System designers may therefore wish to provide for alternative means of data entry in such an event. Prior to the acceptance of symbols of this grade for a particular application, it is recommended that the symbols should be tested with the type of bar code reader to be used to determine that the results are within acceptable limits.

Symbols graded below 0,5 will have had a high proportion of "failed" scan reflectance profiles and are unlikely to perform reliably with any reading equipment.

E.4 Alphabetic grading

In the equivalent ANSI standard X3.182-1990 and certain application specifications, grades are identified using the letters A, B, C, D and F to correspond to the numeric grades 4, 3, 2, 1 and 0 respectively used in this International Standard.

Overall symbol grading using this scheme is in accordance with Table E.1.

Table E.1 — Overall symbol grading - Numeric and alphabetical (ANSI) grading equivalence

Numeric range	Alphabetic grade
3,5 to 4,0	A
2,5 to 3,5	B
1,5 to 2,5	C
0,5 to 1,5	D
below 0,5	F

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex F
(informative)

Guidance on selection of light wavelength

5.1 and 5.2.1 of this International Standard require measurements to be made using the wavelength of light which the intended scanning environment will use. If, as may happen, an application specification does not specify the light source, a judgment must be made in order to determine the most likely wavelength, to enable valid measurements to be made and to be sure that the results will be properly indicative of likely scanning performance in the application.

F.1 Light sources

Light sources for bar code scanning applications normally fall into two broad areas, namely visible light and infra-red light, although a very few highly specialised applications may call for light sources of unusual characteristics such as ultra-violet for fluorescent bar code symbols.

Visible light scanning normally uses light sources with a peak wavelength in the red part of the spectrum, between 620 and 700 nm. Infra-red scanning uses sources with peak wavelengths between 720 and 940 nm.

The most common light sources used for bar code scanning are:

a) Helium-neon laser (633 nm)

b) Light-emitting diode (numerous wavelengths, both visible and infra-red)

c) Solid-state laser diode (numerous wavelengths, both visible and infra-red)

d) Incandescent lamp (nominally white light)

The key characteristics of these are as follows.

A **helium-neon laser** is a gas-filled laser tube which emits highly monochromatic coherent light at a peak wavelength of 632,8 nm (most usually rounded to 633 nm), in the visible red area of the spectrum.

A **light-emitting diode** is a low-power solid-state component most frequently found as the light source in a light pen (wand) or CCD scanner. Operating wavelengths in the visible spectrum may be from 620 to 680 nm; most commonly either 633/640 or about 660 nm. In the infra-red spectrum, 880-940 nm is the most common range of wavelengths.

Typical wavelengths used by **solid-state laser diodes** at the date of publication of this standard are 780 nm (infra-red) and, in the visible spectrum, 660 and 680 nm. They are frequently found in hand-held (laser) scanning equipment and a number of fixed scanners.

In bar code scanning applications, **incandescent lamps** are mainly found in systems using CCD array camera and image processing technology rather than scanning techniques. The light source has a power distribution covering much of the visible spectrum and well into the infra-red spectrum; optical characteristics are defined in colour temperature terms rather than in those of peak wavelength, because of the wide bandwidth and relative absence of peaks in the power distribution. When used in conjunction with a Wratten 26 filter, the light characteristics of a 2856°K lamp approximate to those of a 620-633 nm source.

NOTE Wavelengths stated above may change as the technology evolves.

--`,,```,,,,````-`-`,,`,,`,`,,`---
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
© ISO/IEC 2000 – All rights reserved
Not for Resale

F.2 Effect of variations in wavelength

The reflectance of a substrate or bar code symbol element varies with the wavelength of the incident light. A black, blue, or green printed area will tend to absorb visible red light strongly (and appear therefore of low reflectance), whereas a white, red or orange area will reflect most of the incident light. In the infra-red spectrum, the apparent colour of the element does not correlate at all with reflectance; it is the nature of the pigmentation used (for example the proportion of carbon content) which governs reflectance. Taking reflectance measured at 633 nm as a reference, when measured at 660 or 680 nm the results may differ significantly, and sufficiently to cause the symbol grade to change by one or two units, or even more in the case of bars printed on some thermal papers.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex G
(informative)

Guidance on number of scans per symbol

Bar code symbols are designed to provide a considerable degree of vertical redundancy of the information contained in them. Localised defects and variations in symbol characteristics may occur in the height of the symbol, resulting in the likelihood of scan reflectance profiles from different scan paths across the symbol differing significantly. It is therefore necessary to assess the overall symbol quality by averaging scan reflectance profile grades from multiple scan paths.

The minimum number of scans per symbol as defined in 5.2.5 should normally be ten, or the height of the inspection band divided by the measuring aperture diameter, whichever is lower.

Where the production process (in particular in the circumstances defined in annex J.1) has been shown to be subject to a relatively low incidence of the defects and variations referred to above, through documented formal quality assurance procedures in accordance with ISO 9000 and related standards, the number of scans per symbol may be reduced in order to simplify the process of assessment of large numbers of symbols. Refer to annex J.2 for details of this reduction.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex H
(informative)

Example of verification report

There exists a wide range of verification equipment designed to measure the quality of bar code symbols. Figure H.1 illustrates an example report produced by one of these devices (assuming that the report below was obtained with the use of a measuring aperture of 0,250 mm diameter (ref. no. 10) and with a 660 nm light source. The grade should therefore be reported as 3,0/10/660).

VERIFICATION REPORT			
Date	**23.12.96**	Time	**16:12:36**
Aperture:	**0,010 in / 0,25 mm**	Wavelength:	**660 nm**
Code type:	**Code 39**	Decoded data:	**$M**
Overall Symbol Grade:	**3.0 (B)**	Averaged over (no. of scans):	**1**
Last scan reflectance profile grade:	**3.0 (B)**		
Scan reflectance profile analysis			
Parameter	**value**	**grade**	
Decode	Yes	4	
R_{max}	79%	N/A	
R_{min}	2%	4	
Global threshold	40%	N/A	
Symbol contrast	77%	4	
Min. edge contrast	48%	4	
Modulation	0,63	**3***	
Defects	0,16	**3***	
Decodability	0,75	4	
PCS	0,97	N/A	
Average bar gain	+ 3.0%	N/A	
* indicates parameter grade(s) determining scan reflectance profile grade			

Figure H.1 — Example of verification report

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex I
(informative)

Comparison with traditional methodologies

I.1 Traditional methodologies

Traditionally, two methodologies have been used to assess print quality in certain application standards. Advice is given in this International Standard to assist users, particularly producers of symbols, to compare the results obtained with these traditional parameters, which are:

a) The measurement of bar element widths, and particularly the amount of gain or loss from the nominal element dimensions;

b) The calculation of a print contrast signal (PCS) value from the reflectance values R_L and R_D.

Where the symbols are used in an application which does not specify print quality in terms conforming with this International Standard, these two parameters may be measured as part of the procedure to assess symbol quality, and should be measured especially for the purposes of process control in symbol production (see annex J). However, they are excluded from the grading scheme of this International Standard because the criteria for acceptance or failure which they use do not reflect the behaviour of scanning systems. Their inclusion in this International Standard as optional measured, but ungraded, parameters is to enable historical quality information to be correlated with the methodology specified herein.

I.2 Correlation of Print Contrast Signal with symbol contrast measurements

The specifications of a number of bar code applications provide for the contrast between bars and spaces or background to be assessed in terms of print contrast signal (PCS); these specifications define a minimum value of PCS for acceptability. In some cases, this is a fixed value (e.g. PCS_{min} = 0,75 is a commonly specified value); in others, PCS_{min} is itself a function of the background reflectance.

Print contrast signal is calculated according to the following equation:

$$PCS = (R_L - R_D)/R_L$$

where: R_L is the background (space) reflectance;

R_D is the bar reflectance.

Many of the specifications referred to above do not define the points at which R_L and R_D are measured. There is therefore a risk of inconsistency in the value determined for PCS. Furthermore the profile evaluation techniques defined in this International Standard more closely represent the nature of bar code scanning than do methods based on PCS. Consequently when PCS is used for print quality evaluation, symbols that offer good reliable performance may fail the minimum PCS requirement and symbols that meet it may not scan reliably.

It is, however, possible to relate PCS measurements approximately to Symbol Contrast measurements by taking R_L as equal to R_{max} and R_D as equal to $R_{min.}$ This assumption may not represent the actual measurement of PCS by a given device, and care should be taken before placing reliance on such assumed equivalence. PCS and SC may then be calculated from each other as follows:

$$PCS = SC / R_{max}$$

$$SC = PCS \times R_L$$

--`,,```,,,,````-`-`,,`,,`,`,,`---

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

NOTE Scan reflectance profiles in which PCS < 0,50 (when calculated on the assumption given above) will fail the R_{min} test of this International Standard (see 5.4.5 and 6.1.2) and will therefore be graded 0.

I.3 Guidance on grading for applications also specifying PCS

In applications which have based contrast requirements on PCS and need to specify quality grading requirements under this International Standard, the following options may be applied:

a) for symbols with generally high background reflectance, define a minimum overall symbol grade covering all parameters, based on the value of SC derived from the value of PCS_{min} specified by the application multiplied by the lowest background reflectance likely to be encountered in the application, or

b) for applications where a substantial number of low background reflectance symbols may be used (where R_{max} is, for example, typically less than 45 %), define a minimum grade for all parameters except symbol contrast, and a separate (lower) grade for symbol contrast on a similar basis to a). This minimum grade may need to be marginally higher than would have been provided for under a) in order to offset the effects of the low symbol contrast.

These provisions would be applicable if:

— the application specification defines a minimum level of PCS for acceptability but not a minimum grade in accordance with this International Standard, and

— acceptably low levels of scanning problems are encountered with symbols on low-reflectance backgrounds but that comply with the minimum PCS requirements of the specification.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Annex J
(informative)

Process control requirements

This annex describes the application of the scan reflectance profile analysis methodology as a source of feedback useful to the control of the principal variables in the symbol production process. These are, most importantly, element width gain or loss and, secondly, the symbol contrast. The method by which correction is applied is a function of the symbol production method used and is not specified here.

For process control purposes the average of the grades or the values for certain parameters obtained from all the scan reflectance profiles may prove informative. The parameters most likely to be of use are symbol contrast, decodability and modulation (grades or values) and bar width gain or loss (value).

J.1 Process control for repetitive printing

For purposes of process control of symbol production involving

— repetititive printing of the same symbol from the same printing plate or similar material, or high-volume production of symbols by on-demand processes, and

— formal quality assurance procedures (which should conform with ISO 9000, ISO 9001 and/or ISO 9002), designed to ensure consistency of print quality for the image area as a whole throughout the print production run, for example in the production of printed packaging materials,

the following recommendations may be applied

— Sampling frequency and sample size should be specified as part of the symbol producer's formal quality assurance procedures and should be sufficient to enable detection of significant symbol quality deviations.

— The minimum acceptable symbol grade shall be defined.

— The minimum number of scans across each symbol should be determined as set out in annex J.2, dependent on the variability of the symbol production process and on the amount by which the overall symbol grades achieved exceed the minimum acceptable grade defined in accordance with clause 6.

In the circumstances provided for by this section, equipment designed for on-line assessment of symbol quality at production speeds may perform the defined number of scans by scanning different positions across a number of symbols produced in sequence within a short time period, and analyse the resulting scan reflectance profiles as though they referred to multiple scans of the same symbol. However, this approach is not an exact substitute for taking samples in accordance with 5.2.4 because it may not sample through the full height of the inspection band.

J.2 Number of scans

The number of scans during initial production runs (with particular combinations of production process or equipment, substrates and other materials) should be as specified in 5.2.5. Once a quality trend has been determined in terms of the excess of the overall symbol grade achieved over the minimum grade for acceptability defined in accordance with 6, the number of scans may be reduced to that shown in Table J.1 below, in which the columns headed 'Grade excess' represent the excess of the grade achieved over the minimum acceptable grade.

The number of scans for the first three symbols in any production batch should be based on the expected grade difference as determined by past experience; thereafter it should be based on the moving average of the grade differences achieved for the latest three symbols measured.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Table J.1 — Number of scans

Minimum acceptable grade					
≥3,5			≥2,5	≥1,5	≥0,5
Grade excess	No. of scans	Grade excess	No. of scans		
≥0,2	2	≥0,4	2	3	3
≥0,1	3	≥0,3	3	4	4
<0,1	5	≥0,15	4	6	6
		<0,15	5	8	10

J.3 Bar width deviation

The measurement of average bar width gain or loss has been traditionally used as part of a process control procedure to measure print quality. The average bar width gain or loss should be calculated and expressed either directly in dimensional terms or as a percentage of the X dimension (or, if no X dimension has been specified, of the Z dimension) to provide feedback enabling the printing process to be adjusted, which will lead directly to improved decodability and other grades. This factor is not graded since individual element deviations are taken into account in the decodability assessment.

J.3.1 Two-width symbologies

In the case of two-width symbologies, the achieved Z dimension and the achieved wide:narrow ratio N for the symbol shall be calculated as defined in annex A.1.

Intercharacter gaps shall not be included in these calculations.

J.3.2 (n, k) symbologies

In the case of (n, k) symbologies, the achieved Z dimension shall be calculated as defined in annex A.1.

J.3.3 Average bar width gain/loss

For either type of symbol, the average bar width gain or loss is then given (as a percentage of X or Z) by

$$G = 100 \times (\sum_b - \sum_i) / (X \times b)$$

where: X (and Z if necessary) are as defined in 4.2 (see note below)

G = bar width gain (if G is negative this represents bar width loss)

$\sum_b$ = sum of achieved bar widths

$\sum_i$ = sum of nominal bar widths (see note below)

b = number of bars

NOTE In the above formula, X is replaced by Z if X is unspecified; nominal bar widths are calculated on the basis of the X (or Z) dimension multiplied either by 1 or N for narrow and wide bars respectively in a two-width symbology, or by the number of modules in the bar in a (n, k) symbology.

© ISO/IEC 2000 – All rights reserved

Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

Bibliography

[1] ISO 9000-1:1994, *Quality management and quality assurance standards — Part 1: Guidelines for selection and use*.

[2] ISO 9001:1994, *Quality systems — Model for quality assurance in design, development, production, installation and servicing*.

[3] ISO 9002:1994, *Quality systems — Model for quality assurance in production, installation and servicing*.

[4] ISO 2859-1:1989, *Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection*.

[5] ISO 3951:1989, *Sampling procedures and charts for inspection by variables for percent nonconforming*.

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale

ICS 01.080.50; 35.040

Price based on 34 pages

© ISO/IEC 2000 – All rights reserved
Copyright International Organization for Standardization
Provided by IHS under license with ISO
No reproduction or networking permitted without license from IHS
Not for Resale