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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html. In the IEC, see www.iec.ch/understanding-standards.

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.

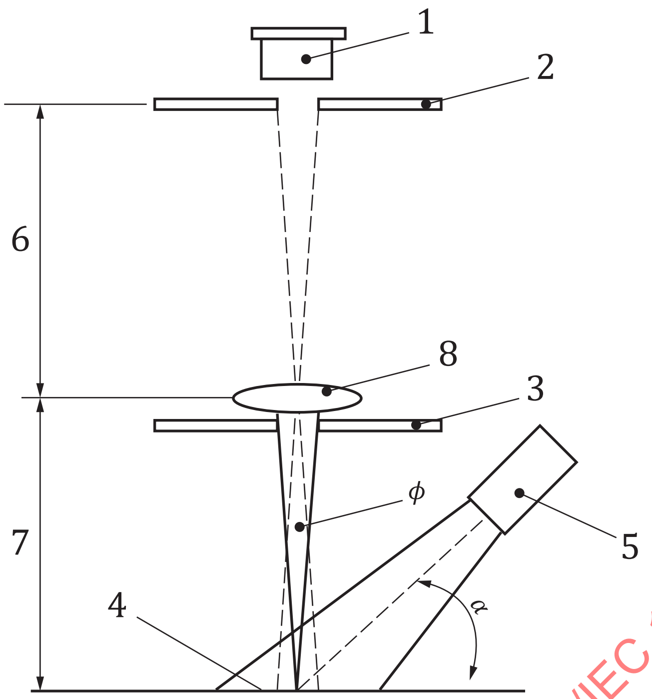
The light reflected from a circular sample area of the surface shall be collected within a cone; the angle at the vertex of which is 15°, centred on the perpendicular to the surface, through a circular measuring aperture, the diameter of which at 1:1 magnification shall be equivalent to that of the sample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



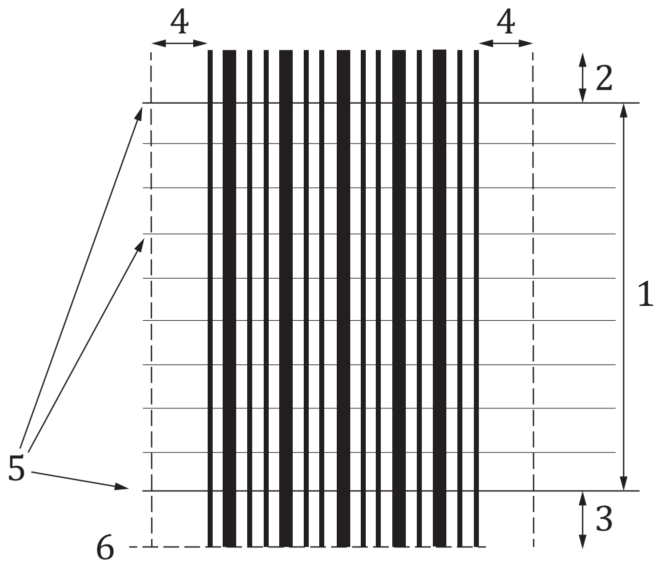
Key

1 light sensing element
2 aperture at 1:1 magnification (measurement 6 is equal to measurement 7)
3 baffle
4 sample
5 light source
6 image distance
7 object distance
8 lens
α incident light angle
ϕ collected light cone angle

Figure 1 — Reference optical arrangement

5.2.5 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 while the upper line shall be positioned 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.



Key

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

5.2.6 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 10 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.

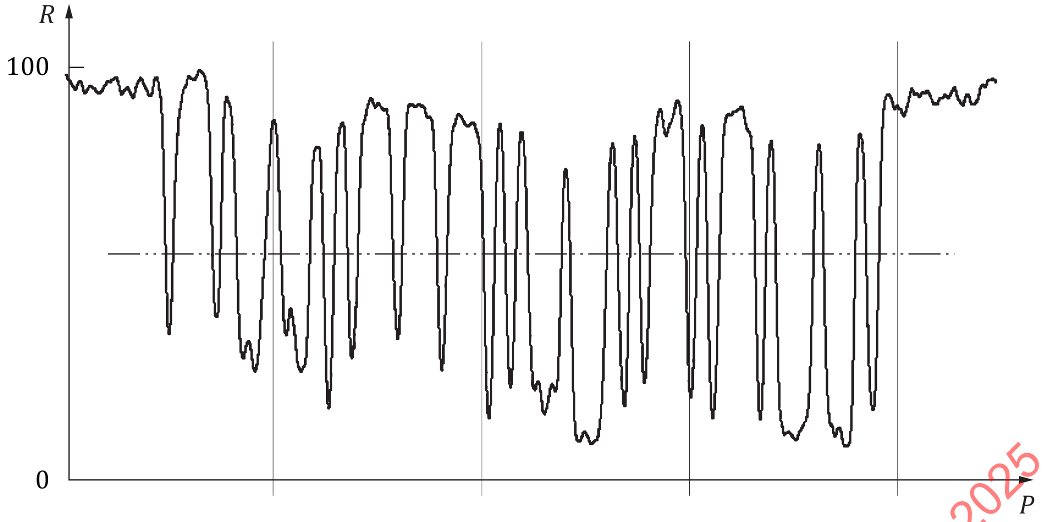
The overall quality grade of the symbol is determined by averaging the quality grades of the individual scans, in accordance with Clause 6.

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 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.

NOTE The measurement tolerances are specified in ISO/IEC 15426-1.

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 %.



Key

P linear position

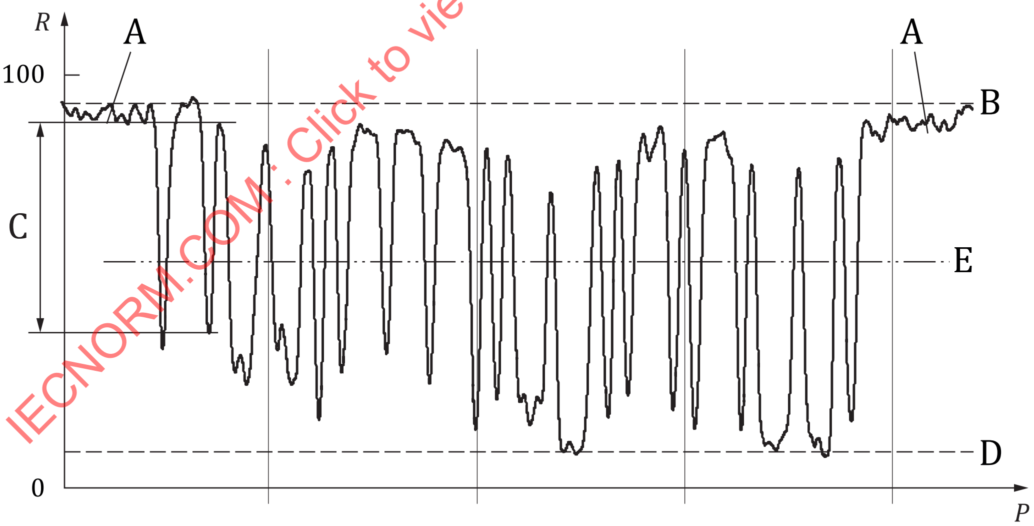
R reflectivity

Figure 3 — Scan reflectance profile

5.4 Scan reflectance profile assessment parameters

5.4.1 General

The scan reflectance profile parameters described in 5.4.2 to 5.4.9 shall be assessed for compliance with this document. Grading of the scan reflectance profile parameters is described in 6.2. Figure 4 is the same scan reflectance profile as Figure 3 with certain features indicated.



Key

A quiet zones (left and right)

B R_{max} is equal to the average of the highest 3 %

C ΔR_{Emin}

D R_{min} is equal to the average of the lowest 3 %

E global threshold

R reflectivity

P linear position

Figure 4 — Features of scan reflectance profile

5.4.2 Element determination

To locate the bars and spaces, a global threshold shall be established. The global threshold, T_G shall be calculated using the algorithm in Annex B.

NOTE 1 Using the algorithm in Annex B is a new feature of this revision of this document and is meant to reduce grade fluctuations that arise from changes in the global threshold from small areas of extreme values of reflectance within the scan reflectance profile.

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.

For each space, $R_s - T_G$ represents its reflectance margin above the global threshold. For each bar, $T_G - R_b$ represents its reflectance margin below the global threshold. A warning should be issued when the minimum reflectance margin for any element is less than 5 % of the symbol contrast of a symbol. This warning should caution users to consider the possibility that this symbol is close to a failing grade for edge determination.

NOTE 2 This warning is not required but recommended as helpful information to verifier users, especially when intermittent failure of edge determination causes symbol grade variation.

5.4.3 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 shall fail the decode parameter. The quiet zones and intercharacter gaps, if any, are considered to be spaces.

5.4.4 Decode

The symbology reference decode algorithm shall be used to decode the symbol using the element edges determined in steps 5.4.2 and 5.4.3. This algorithm can be found in the symbology specification.

5.4.5 Symbol contrast

Symbol contrast is calculated as:

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

where

R_{max} is the average of the highest 3 % of sampled reflectance values within the scan reflectance profile, bounded by the extent of the left and right quiet zones;

R_{min} is the average of the lowest 3 % of sampled reflectance values within the scan reflectance profile, bounded by the extent of the left and right quiet zones.

NOTE The use of an average for R_{max} and R_{min} is a new feature introduced into this revision of this document and is intended to reduce measurement variability due to small areas of aberrant reflectance that is sometimes, but not exclusively, caused by specular reflection.

5.4.6 Edge contrast

Edge contrast is the difference between the R_s and R_b of adjoining elements including quiet zones. Edge contrast is computed for each edge in the symbol and the lowest value of edge contrast found for any edge in the scan reflectance profile is the minimum edge contrast.

5.4.7 Modulation

Modulation is calculated as:

$$\Delta R_{MOD} = \Delta R_{Nmax} / \Delta R_{SC}$$

5.4.8 Defects

Defects are irregularities found within elements and quiet zones. Defects 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, ΔR_{Nmax}, to symbol contrast. The element non-uniformity is modified according to a), b) and c), and calculated in d) in a way that reduces the impact of small variations in reflectivity.

a) Define the defect adjustment constant, *c,* as $c = 0{,}075 \times \Delta R_{SC}$, where ΔR_{SC} is the SC of the SRP.

NOTE 1 *c* corresponds to the following:

— a small amount of “noise” to be reduced to eliminate instability in measurement;

— an amount of contrast difference that is small enough for scanners to ignore.

NOTE 2 The original definition of "defect", prior to the previous revision of this document, corresponds to a constant *c* value of 0.

b) For each bar element

1) for each positive peak maxima in the element:

i) find the lowest valley to the left of it within the element, called $R_{minLeft}$;

ii) find the lowest valley to the right of it within the element, called $R_{minRight}$;

iii) calculate ERN_{left} as the peak maximum minus the $R_{minLeft}$;

iv) calculate ERN_{right} as the peak maximum minus the $R_{minRight}$;

v) take the lesser of ERN_{left} and ERN_{right} as ERN′ (ERN prime);

vi) if ERN′ ≥ *c*, set F to the value 1; if ERN′ < *c*, calculate F = ERN′/c;

vii) calculate the provisional ERN for this peak only as F multiplied by the maximum of (ERN_{left}, ERN_{right}).

2) take the maximum of the provisional ERN values from all iterations of the previous step as the ERN of this element.

c) Same as b) for each space element, and as follows.

1) For each negative valley minima (a local minima):

i) find the highest peak to the left of it within the element, called $R_{maxLeft}$;

ii) find the highest peak to the right of it within the element, called $R_{maxRight}$;

iii) calculate ERN_{left} as $R_{maxLeft}$ minus the valley minimum;

iv) calculate ERN_{right} as $R_{maxRight}$ minus the valley minimum;

v) take the lesser of ERN_{left} and ERN_{right} as ERN′ (ERN prime);

vi) if ERN′ ≥ c, set F to the value 1; if ERN′ < c, calculate F = ERN′/c;

vii) calculate the provisional for this valley only as F multiplied by the maximum of (ERN_{left}, ERN_{right}).

2) Take the maximum of all the provisional ERN values from all iterations of c) 1) as the ERN of this element.

d) Take the maximum of all ERN values from b) 2) and c) 2) as ΔR_{Nmax} for the overall scan:

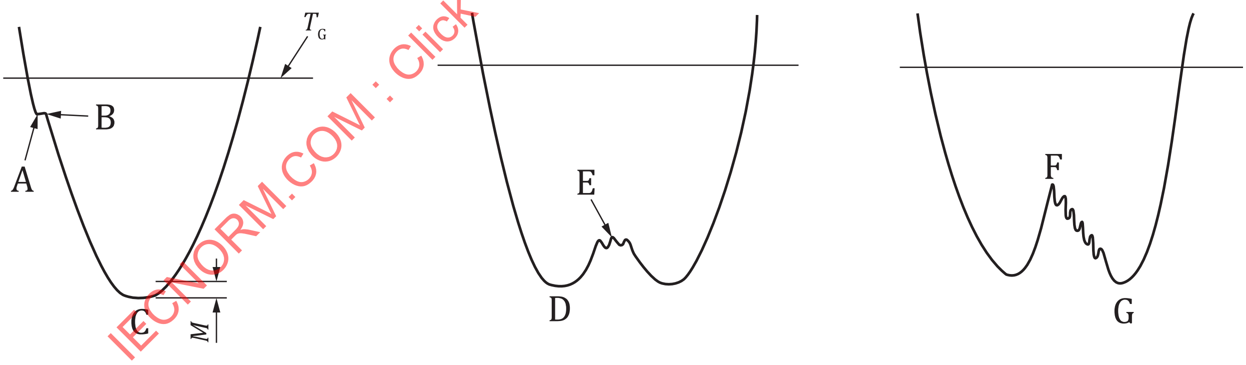
$$D_F = \Delta R_{Nmax} / \Delta R_{SC}$$

To illustrate the functioning of this algorithm, three examples are given in in Figure 5 of a section of an SRP, each showing the reflectivity of bar elements which contain one or more peaks and valley minima. The horizontal line labelled T_G represents the global threshold. The symbol M in Figure 5 shows the reflectivity difference that is equal to the constant c times the symbol contrast.

The leftmost portion of the SRP shown in Figure 5 is an example of a case in which the defect value will be reduced because the difference in reflectivity between point B and A is less than the height of element M. The defect will be reduced because ERN_{left}, which is the difference in reflectivity between A and B, is very small (in particular, it is much less than the height of element M) and therefore the factor F will be correspondingly small in step c) vi). The defect for this element will therefore be a small factor multiplied by the difference in reflectivity between B and C.

The middle portion of the SRP shown in Figure 5 is an example that shows a case where many peaks and valleys exist within an element, but ERN_{left} (the difference between E and D) is much larger than the height of element M. Therefore, defect measurement is not be affected by step c) vii because the factor F will be set to 1 in step c) vi).

The rightmost portion of the SRP shown in Figure 5 is an example is actually equivalent to the middle example in as much as this algorithm is concerned, even though ERN_{left} and ERN_{right} are different for each local maxima. In particular, the difference in reflectivity between F and G is again much larger than the height of M, and therefore the factor F will be set to 1 in step c) vi).



a) Defect is reduced **b) Defect is not reduced** **c) Defect is not reduced**

Key

A local minimum in first example element

B local maximum in first example element

C element minimum of first example element

D element minimum of second example element

E local maximum in second example element

F local maximum in third example element

G element minimum in third example element

Figure 5 — Examples to illustrate ERN calculation

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 to the measurements required by the reference decode algorithm in the relevant symbology specification. In the following paragraph, the term "measurement" shall be taken to refer to either

— a single element width in symbologies which use these directly in the reference decode algorithm (e.g. “Code 39”), or

— the combined width of two or more adjacent elements in symbologies which use edge to similar edge measurements for decoding (e.g. “Code 128”).

The decodability value is calculated with reference to the following:

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

b) the reference threshold applicable to measurements of the same type as A (D_T);

c) the actual measurement showing the greatest deviation from A in the direction of the reference threshold, M.

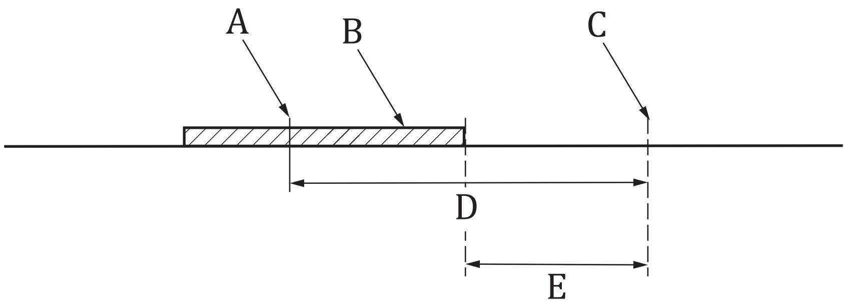
V can be calculated as follows:

$$V = |(D_T - M)/(D_T - A)|$$

where

$\| \|$	represents the absolute value function;
$(D_T - M)$	is the remaining margin not used by printing variation;
$(D_T - A)$	is the total theoretical margin based on the ideal measurement of the element(s).

Figure 6 illustrates this principle.



Key

A average element width

B width of most deviant element

C reference threshold

D total margin available

E remaining margin

The shaded area represents the range of measurements of the same type as A (e.g. narrow elements).

Figure 6 — 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 specific computation of decodability unique to each symbology.

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.

6 Symbol grading

6.1 General

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 document, following the guidelines in Clause 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 assigned a grade on a descending scale from 4,0 to 0 in steps of 0,1. The grade 4,0 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. An example of a symbol quality grading is given in Annex C. For the interpretation of the scan reflectance profile and profile grades, see Annex E. Annex I compares information related to the methodology described in this document to other older methodologies of bar code print quality control that are considered traditional methodologies.

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 Clause E.2. For process control purposes, the averages of the grade for each parameter obtained from all the scan reflectance profiles often provide meaningful guidance (see Clause J.5). If the grades alone do not provide sufficient explanation, it can sometimes be necessary to examine the plot(s) of the scan reflectance profile(s).

6.2 Scan reflectance profile grading

6.2.1 General

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

a) decode;

b) symbol contrast;

c) minimum reflectance (R_{min});

d) minimum edge contrast (ΔR_{Emin});

e) modulation;

f) defects;

g) decodability;

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

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

6.2.2 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 4,0.

6.2.3 Reflectance parameter grading

Depending on their values, symbol contrast, modulation and defects are graded from 4,0 to 0 in steps of 0,1; minimum reflectance and minimum edge contrast grades are graded as either 4,0 or 0. These parameters are interdependent and need to be considered together.

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

Table 2 — Reflectance parameter grading

Grade	R_{min}	ΔR_{SC}	ΔR_{Emin}	R_{MOD}	D_F
4,0	≤0,5 R_{max}	≥0,70	≥0,15	≥0,70	≤0,15
3,0 to 3,9		≥0,55 and <0,70		≥0,60 and <0,70	≤0,20 and >0,15
2,0 to 2,9		≥0,40 and <0,55		≥0,50 and <0,60	≤0,25 and >0,20
1,0 to 1,9		≥0,20 and <0,40		≥0,40 and <0,50	≤0,30 and >0,25
0 to 0,9		≥0,15 and <0,20		≥0,30 and <0,40	
0	>0,5 R_{max}	<0,15	<0,15	<0,30	>0,30

For SC, MOD and defects, the grade shall be computed as an interpolated value, rounded down the next 0,1 in between grade levels. For example, a SC of 52 % results in a grade of 2,8 and a MOD of 0,69 results in a grade of 3,9. For the SC example, the decimal part of the SC grade is computed as the fraction of the range for the grade of 2 (15 %) that the measured value (52 %) exceeds the minimum value for a grade of 2 (40 %), computed as 2 + [(52 % − 40 %)/15 %] which is 0,8. In the lowest range (grades below 1,0), the grade shall be interpolated from 1 down to 0, except defect which shall be 0 for all values greater than 0,30.

NOTE By rounding down to the next 0,1, a value that is close to but not equal to or exceeding the next boundary, is not rounded to the grade for the next higher level. For example, a value for a SC of 69,9 % would be graded as 3,9 rather than 4,0.

6.2.4 Decodability

The decodability value, *V*, for each scan reflectance profile shall be calculated in accordance with 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 4,0 to 0, rounded down to the next 0,1, in between grade levels according to Table 3. For example, a value *V* of 0,56 results in a grade of 3,5 and a *V* of 0,20 results in a grade of 0,0.

Table 3 — Decodability grades

V	Grade
≥0,62	4,0
≥0,50 and <0,62	3,0 – 3,9
≥0,37 and <0,50	2,0 – 2,9
≥0,25 and <0,37	1,0 – 1,9
≥0,20 and <0,25	0,0 – 0,9
<0,20	0

6.3 Expression of symbol grade

A symbol grade is only meaningful if it is expressed in conjunction with the measurement light source and aperture used. It should be shown in the format

G/A/L/Y

where

G indicates the overall symbol grade, i.e. the arithmetic mean of the scan reflectance profile grades to one decimal place;

A indicates the aperture reference number, from Table 1;

L indicates the light source, by the light peak wavelength in nanometres for narrow band illumination, the letter “W” for white (broad band) illumination, or other designator defined by an application specification;

Y indicates the lighting angle (optional for the default of /45), with or without a light specifier, as appropriate.

For example, 2,7/05/660 indicates that the average of the grades of the scan reflectance profiles is 2,7 when these scan reflectance profiles are obtained with the use of a 0,125 mm aperture (reference number 05) and a 660 nm light source.

If a verifier setup of ISO/IEC 15415, using lighting from four sides, is used (see 5.2.4) the lighting specifier shall be included in the formal grade and shall explicitly indicate the lighting specifier, such as /45Q for 4-side light from 45°.

Annex A
(normative)

Decodability

A.1 General

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.2 Two-width symbologies

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

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

Then,

$$V_1 = (D_T - e)/(D_T - Z)$$

$$V_2 = (E - D_T)/[(N \times Z) - D_T]$$

V_C is equal to the lesser of V_1 or V_2

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.3 Edge to similar edge decodable symbologies [(n, k) symbologies]

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

$$Z = \text{avg}(S)/n$$

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

— for all $j = 1$ to $n - 2(k - 1)$:

$$T_j = [(j + 0{,}5) \times S]/n$$

— for all $i = 1$ to $2(k - 1)$ and all $j = 1$ to $n - 2(k - 1)$, K is equal to the smaller of absolute value of $(e_i - T_j)$ or the previous value of K, where e_i is the measurement from the leading edge of element i to the 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.

Annex B
(normative)

Threshold calculation algorithm — Algorithm description

Start by creating a histogram of all sampled reflectance values within the scan reflectance profile, bounded by the extents of the right and left quiet zones, and proceed as follows:

a) Initialize the variable minVariance to a very large number and initialize Tmin and Tmax to zero.

b) For every grey-scale value, "t", starting from the lowest grey-scale value to the highest grey-scale value (0 to 255 for an 8-bit image sensor):

   1) compute the mean and variance of pixels below t and call it MeanDark and VarianceDark;

   2) compute the mean and variance of pixels above or equal to t and call it MeanLight and VarianceLight;

   3) compute Variance = VarianceLight + VarianceDark;

   4) if Variance < minVariance, save Variance in minVariance and save t in Tmin;

   5) if Variance = minVariance save t in Tmax.

   NOTE This step is used to break ties. Tmin is the smallest grey-level where the variance is the minimum and Tmax is the largest grey-level where the variance is the same minimum.

c) If Tmax is zero, then optimal threshold T = Tmin; otherwise, T = (Tmin + Tmax) / 2.

Annex C
(informative)

Example of symbol quality grading

C.1 Individual scan reflectance profile grading

This annex illustrates the determination of the grades for the scan reflectance profile similar to that shown in Figure 3, assuming measurement using a 900 nm (infrared) light source and a 0,125 mm aperture. The particular values used in this example are meant to be illustrative and do not necessarily match Figure 3 precisely.

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

The minimum reflectance, R_{min} is 10 % while the maximum reflectance, R_{max}, is 82 %. The global threshold is determined to be 46 % by Annex B. R_{min} satisfies the (0,5 × R_{max}) test by being less than:

0,5 × 82 % = 41 %.

Symbol contrast is given by:

ΔR_{SC} = 82 % − 10 % = 72 %.

Minimum edge contras, ΔR_{Emin}, occurs on edge 4, where R_s and R_b are 76 % and 34 %, respectively. ΔR_{Emin} is 76 % − 34 % = 42 %.

R_{MOD} 42 % / 72 % = 0,58

The maximum element reflectance non-uniformity (ΔR_{Nmax}) the largest non-uniformity or the defects in a scan reflectance profile, can be found as the result of a void in element 7, a bar. ΔR_{Nmax} is equal to 36 % − 24 % = 12 %. Note that the ΔR_{Nmax} can be in any bar, space or quiet zone. The defects value is therefore:

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 (see Table C.1).

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

Parameter	Value	Grade
Decode		4,0
R_{max}	82 %	
R_{min}	10 %	4,0
SC	82 % − 10 % = 72 %	4,0
ΔR_{Emin}	76 % − 34 % = 42 %	4,0
MOD	42 % / 72 % = 0,58	2,8
D_F	12 % / 72 % = 0,17	3,6
Decodability	0,58	3,6

Since the lowest individual grade, in this instance the grade for MOD, is 2,8, the scan reflectance profile grade is also 2,8.

C.2 Overall symbol grade

Assuming that a series of 10 scans of the symbol used in Figure 3 gave the following scan reflectance profile grades:

2,1; 2,1; 3,0; 3,1; 4,0; 2,0; 2,1; 1,9; 3,1; 2,8

The arithmetic mean of these grades is 2,62. This mean shall be truncated to only one digit after the decimal point. That is, any decimal digit after the first is ignored (rather than rounded mathematically). As a further example, 2,699 shall be truncated to 2,6.

Hence, in this example the overall symbol grade, is 2,6. The result should be reported in the form:

2,6/05/660

If 4-sided lighting from 45° was in used, this would be reported as:

2,6/05/660/45Q

Annex D
(informative)

Substrate characteristics

D.1 General

In certain circumstances (e.g. the design and production of printed packaging materials incorporating bar code symbols), it can be necessary or preferable to assess the acceptability of either substrates or ink colours, or both, for a given bar code application, before a bar code symbol is available, which can be tested in accordance with this document.

D.2 Substrate opacity

The symbol shall be graded in accordance with the reflectance parameters in 6.2.3 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:

$$R_2 / R_1$$

where

R_1 is the reflectance of a sample sheet of the substrate backed with a white surface the reflectance of which is 89 % or greater;

R_2 is the reflectance of the same sample sheet backed with a black surface of not more than 5 % reflectance.

D.3 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 can yield grades differing from those obtained by the use of the reference optical arrangement.

D.4 Over-laminate

A symbol intended to be covered with a protective lamination should be graded according to the reflectance parameters in 6.2.3 when measured with the laminate in place. The thickness of the laminate including its adhesive should be as small as possible in order to minimize its effects on the reading performance of the symbol.

D.5 Static reflectance measurements

D.5.1 General

In some cases, it is preferable 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, predicts as closely as is generally possible, the results that will be obtained when the symbol is scanned dynamically.

Static reflectance measurements should be made with the wavelength of light, the aperture size and the optical arrangement which relate to the application and which are specified in accordance with 5.2.2 to 5.2.4.

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.5.2 Prediction of symbol contrast

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 10× 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 2× to 3× wide and which matches the colour in which the bars are to be printed.

The predicted value of SC, $\Delta R'_{SC}$, can then be calculated as follows:

$$\Delta R'_{SC} = R_{max} - R_{min}$$

D.5.3 Prediction of minimum edge contrast, ΔR_{Emin}, and modulation

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 ΔR_{Emin} requires that measurements of reflectance be made on samples which simulate the smallest reflectance difference which is found between adjacent elements. It is probable that in most bar code symbols, this condition is found where a light and a dark element which are each 1× 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.

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 minimized, 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 20× 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 edge contrast, $\Delta R'_{Emin}$, can then be calculated as the difference between R_s and R_b.

For materials which do not satisfy the tests for opacity, which are detailed in Clause D.2, the measurements which are made for the purpose of predicting ΔR_{SC} and ΔR_{Emin} 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 ΔR_{Emin} 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 as the ratio of $\Delta R'_{Emin}$ and $\Delta R'_{SC}$.

D.5.4 Acceptability of measured and derived values

All the grades corresponding to the static values of SC and ΔR_{Emin} and to the derived value for modulation shall be equal to or higher than the minimum overall symbol grade specified for the application.

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 should 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, significant additional information may be derived by averaging the grades obtained for each parameter for all scan reflectance profiles. In particular, 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.

The bar width gain

— may be reported directly (as an average);

— reduces EC;

— reduces MOD;

— reduces decodability

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

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

— can cause decode failure if excessive.

The bar width loss

— may be reported directly (as an average);

— increases EC initially; when excessive, reduces EC;

— increases MOD initially; when excessive, reduces MOD;

— can increase R_{min};

— reduces decodability

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

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

— can cause decode failure if excessive.

The irregular element edges

— cause variations in decodability between scan reflectance profiles;

— may cause decode failure if excessive.

The uneven inking

— decreases EC;

— decreases MOD;

— can increase ΔR_{Nmax};

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

Voids and/or specks

— increase ERN;

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

— can cause edge determination failure.

E.3 Matching grades to applications

Symbols with differing grades can give good performance in practice given 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;

— the availability of scanning equipment with multiple scan paths.

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

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 can 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 can 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 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 document.

Overall symbol grading using this scheme is done according to Table E.1.

Table E.1 — Overall symbol grading — Numeric and alphabetical 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

Annex F
(informative)

Guidance on selection of light wavelength

F.1 General

Subclauses 5.1 and 5.2.2 require measurements to be made using the wavelength of light which the intended scanning environment will use. If, as can happen, an application specification does not specify the light source, a judgment needs to 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.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 infrared spectrum, the apparent colour of the element does not correlate at all with reflectance; it is the nature of the pigmentation used (e.g. the proportion of carbon content) which governs reflectance. Taking reflectance measured at 633 nm as a reference, when measured at 660 nm or 680 nm, the results can 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.

Annex G
(informative)

Guidance on the number of scans per symbol

Bar code symbols are designed to provide a considerable degree of vertical redundancy of the information contained in them. Localized defects and variations in symbol characteristics can 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 5.2.6 should normally be 10 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 Clause 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 Clause J.2 for details of this reduction.

Annex H
(informative)

Example of verification report

There exists a wide range of verification equipment designed to measure the quality of bar code symbols. Table H.1 illustrates an example report produced by one of these devices. Assuming that the report in Table H.1 was obtained with the use of a measuring aperture of 0,250 mm diameter (reference number 10) and with a 660 nm light source, the grade should therefore be reported as 3,3/10/660.

Table H.1 — Example of verification report

VERIFICATION REPORT			
Date (YYYY-MM-DD)	2024-09-17	Time (HH:MM:SS)	16:12:36
Aperture:	0,25 mm	Wavelength:	660 nm
Symbology:	Code 39	Decoded data:	$M
Overall symbol grade:	3,3 (B)	Averaged over (no. of scans):	1
Scan reflectance profile analysis			
Parameter	**Value**	**Grade**	
Decode	Pass	4,0	
R_{max}	79 %	NA	
R_{min}	2 %	4,0	
Global threshold	41 %	NA	
Symbol contrast	77 %	4,0	
Min. edge contrast	48 %	4,0	
Modulation	63 %	3,3[a]	
Defects	16 %	3,8	
Decodability	75 %	4,0	
PCS	97 %	NA	
Average bar gain	+3,0 %	NA	

Key

NA not applicable

[a] Parameter grade(s) determining scan reflectance profile grade.

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 document to assist users, particularly producers of symbols, to compare the results obtained with these traditional parameters, which are the following:

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 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 document, 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 document because the criteria for acceptance or failure which they use do not reflect the behaviour of scanning systems. Their optional inclusion as 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 ; these specifications define a minimum value of PCS for acceptability. In some cases, this is a fixed value (e.g. $P_{CS,min}$ = 0,75 is a commonly specified value); in others, $P_{CS,min}$ is itself a function of the background reflectance.

Print contrast signal is calculated according to the following formula:

$$P_{CS} = (R_L - R_D)/R_L$$

where

P_{CS} is the PCS;

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 document 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 can fail the minimum PCS requirement and symbols that meet is not scan reliably.

It is, however, possible to relate PCS measurements to symbol contrast measurements by taking R_L as equal to R_{max} and R_D as equal to R_{min} (an assumption which does not necessarily represent the actual measurement of PCS by a given device). PCS and SC may then be calculated from each other as follows.

$$P_{CS} = \Delta R_{SC} / R_{max}$$