

Bar coding — Test specifications — Bar code symbols

The European Standard EN 1635 : 1997 has the status of a
British Standard

ICS 35.040

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

National foreword

This British Standard is the English language version of EN 1635 : 1997.
The UK participation in its preparation was entrusted to Technical Committee IST/34, Bar coding, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled 'International Standards Correspondence Index', or by using the 'Find' facility of the BSI Standards Electronic Catalogue.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 36, an inside back cover and a back cover.

Amendments issued since publication

Amd. No.	Date	Text affected

This British Standard, having been prepared under the direction of the Information Systems Technology Assembly, was published under the authority of the Standards Board and comes into effect on 15 January 1998

© BSI 1998

ISBN 0 580 28973 7

Foreword

This European Standard has been prepared by Technical Committee CEN/TC 225, Bar coding, the secretariat of which is held by NNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 1998, and conflicting national standards shall be withdrawn at the latest by January 1998.

Organizations contributing to the development of the standard include:

- AIM Europe
- AIM USA

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

	Page
Foreword	2
Introduction	4
1 Scope	4
2 Normative references	4
3 Definitions, symbols and abbreviations	5
3.1 Definitions	5
3.2 Symbols and abbreviations	5
3.2.1 Abbreviations	5
3.2.2 Symbols used in formulae	6
4 Measurement methodology	6
4.1 General requirements	6
4.2 Correlation with traditional methodologies	6
4.3 Reference reflectivity measurements	6
4.3.1 Measurement wavelength(s)	7
4.3.2 Optical geometry	7
4.3.3 Sample area	7
4.3.4 Inspection band	8
4.3.5 Number of scans	9
4.3.6 Process control for repetitive printing	9
4.4 Scan reflectance profile	9

4.5 Profile assessment parameters	9
4.5.1 Element determination	12
4.5.2 Decode	12
4.5.3 Symbol contrast	12
4.5.4 Edge contrast	12
4.5.5 Modulation	12
4.5.6 Defects	12
4.5.7 Decodability	13
4.5.8 Quiet zone check	13
5 Symbol grading	14
5.1 Scan reflectance profile grading	14
5.1.1 Decode	14
5.1.2 Reflectance parameter grading	14
5.1.3 Decodability	14
5.2 Expression of symbol grade	15
6 Other aspects of the symbol	15
6.1 Substrate characteristics	15
6.2 Element widths	15
6.2.1 Average element widths	15
6.2.2 Process control for 'EAN/UPC' symbols	15
6.3 Correlation of symbol contrast with other contrast measurements	15
7 Multi-row symbologies	16
Annexes	
A (normative) Decodability	17
A.1 Applicable symbologies	17
A.2 'Code 39' and 'Interleaved 2 of 5'	17
A.3 'Codabar'	17
A.4 'Code 128'	18
A.5 'EAN/UPC'	19
B (informative) The relationship between bar width deviation and decodability for the 'EAN/UPC' symbology	23
B.1 The V2 factor	23
B.2 Bar width deviation and decodability	24
C (informative) Example of symbol quality grading	27
C.1 Individual scan reflectance profile grading	27
C.2 Overall symbol grade	27

	Page
D (informative) Substrate characteristics	27
D.1 Substrate opacity	27
D.2 Gloss	27
D.3 Over-laminate	27
E (informative) Interpreting the scan reflectance profile and symbol grades	28
E.1 Significance of scan reflectance profiles	28
E.2 Interpretation of results	28
E.3 Grades for process control	28
E.4 Matching grades to applications	29
E.5 Alphabetic grading	29
F (informative) Static reflectance measurements	30
G (informative) Guidance on selection of measurement wavelength	30
G.1 Light sources	30
G.2 Effect of variations in wavelength	31
H (informative) Guidance on number of scans per symbol	31
J (informative) Example of verification report	32
K (informative) Contrast measurements – Comparison of symbol contrast with print contrast signal	34

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 intended to be the subject of a separate European Standard.

This standard is intended to be substantially equivalent in technical content to the corresponding ANSI standard X3.182 – 1990.

The methodology of this standard is complementary to bar code symbol production methods based on adherence to procedures for the specification of variable attributes of the symbol, rather than direct measurement of symbols. It does not invalidate such techniques, but provides independent confirmation of their suitability for the application in question.

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

1 Scope

This European Standard

- specifies the methodology for testing bar code symbols for conformity with the symbology specification;
- defines a range of quality grades based on the measurement of specific attributes of the symbol;
- gives information on possible causes of deviation from optimum grades to enable users to take appropriate corrective action.

This European Standard applies to those symbologies for which a European Standard has been drawn up and its methodology can be applied to other symbologies for which a reference decode algorithm has been defined, including both linear and multi-row symbologies.

2 Normative references

This European Standard incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 797 : 1995	<i>Bar Coding — Symbology Specifications — “EAN/UP”</i>
EN 798 : 1995	<i>Bar Coding — Symbology Specifications — “Codabar”</i>
EN 799 : 1995	<i>Bar Coding — Symbology Specifications — “Code 128”</i>
EN 800 : 1995	<i>Bar Coding — Symbology Specifications — “Code 39”</i>
EN 801 : 1995	<i>Bar Coding — Symbology Specifications — “Interleaved 2 of 5”</i>
prEN 1556	<i>Bar Coding — Terminology</i>
EN ISO 9000-1 : 1994	<i>Quality management and quality assurance standards — Part 1: Guidelines for selection and use</i>
EN ISO 9001 : 1994	<i>Quality systems — Model for quality assurance in design/development, production, installation and servicing</i>
EN ISO 9002 : 1994	<i>Quality systems — Model for quality assurance in production, installation and servicing</i>
ISO 2859-1 : 1989	<i>Sampling procedures for inspection by attributes — Part 1: Sampling plans indexed by acceptable quality level (AQL) for lot-by-lot inspection</i>
ISO 3951 : 1989	<i>Sampling procedures and charts for inspection by variables for percent nonconforming</i>
ISO 7724-2 : 1984	<i>Paints and varnishes — Colorimetry — Part 2: Colour measurement</i>

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of this standard the definitions of prEN 1556, together with the following definitions, apply.

3.1.1 bar reflectance (R_b)

The lowest reflectance value in the profile of a bar element.

3.1.2 decodability (V)

Measure of the proportion of the theoretical tolerance derived from the reference decode algorithm, for the element (or distance) deviating most from its nominal dimension in a scan profile, not consumed by that element or distance.

3.1.3 decode

Determination of the information encoded in a bar code symbol.

3.1.4 edge contrast (EC)

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

3.1.5 element reflectance non-uniformity (ERN)

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

3.1.6 global threshold (GT)

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

3.1.7 gloss

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

3.1.8 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).

3.1.9 modulation (MOD)

The ratio of minimum edge contrast (EC_{min}) to symbol contrast (SC).

3.1.10 peak

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

3.1.11 profile

Scan reflectance profile (plot of variations in reflectance with linear distance along a scan path).

3.1.12 sample area

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

3.1.13 scan path

The line along which the centre of the sample area traverses the symbol.

3.1.14 show-through

The property of a substrate that allows underlying markings or materials to affect the reflectance of the substrate.

3.1.15 space reflectance (R_s)

The highest reflectance value in the profile of a space element.

3.1.16 symbol contrast (SC)

The difference between the maximum and minimum reflectance values in a scan reflectance profile.

3.1.17 valley

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

3.1.18 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.

3.2 Symbols and abbreviations

3.2.1 Abbreviations

3.2.1.1 EC: Edge contrast.

3.2.1.2 EC_{min} : Minimum value of EC.

3.2.1.3 ERN: Element reflectance non-uniformity.

3.2.1.4 ERN_{max} : Maximum value of ERN.

3.2.1.5 GT: Global threshold.

3.2.1.6 MOD: Modulation.

3.2.1.7 N: Achieved wide to narrow ratio.

3.2.1.8 PCS: Print contrast signal.

3.2.1.9 R_b : Bar reflectance.

3.2.1.10 R_D : Bar (dark) reflectance.

3.2.1.11 R_L : Background (light) reflectance.

3.2.1.12 R_{max} : Maximum reflectance.

3.2.1.13 R_{min} : Minimum reflectance.

3.2.1.14 R_s : Space reflectance.

3.2.1.15 RT: Reference threshold.

3.2.1.16 S: Total width of a character.

3.2.1.17 SC: Symbol contrast.

3.2.1.18 SRD: Static reflectance difference.

3.2.1.19 V: Decodability value.

3.2.1.20 Z: Average achieved narrow element dimension.

3.2.2 Symbols used in formulae

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

3.2.2.2 e: Width of widest narrow element.

3.2.2.3 E: Width of narrowest wide element.

3.2.2.4 e_b : Width of widest narrow bar ('Codabar').

3.2.2.5 E_b : Width of narrowest wide bar ('Codabar').

3.2.2.6 e_i : ith edge to similar edge measurement.

3.2.2.7 e_s : Width of widest narrow space ('Codabar').

3.2.2.8 E_s : Width of narrowest wide space ('Codabar').

3.2.2.9 $e_{s'}$: Width of narrowest space in characters with three wide bars ('Codabar').

3.2.2.10 K: Smallest absolute difference between a measurement and a reference threshold.

3.2.2.11 m: Number of modules in a symbol character.

3.2.2.12 M: Width of element showing greatest deviation from A (4.4.7 only); number of dark modules in a symbol character (annexes A.4 and A.5).

3.2.2.13 RT_b : Reference threshold for bar elements ('Codabar').

3.2.2.14 RT_i : Reference threshold between measurements i and (i + 1) modules wide.

3.2.2.15 RT_s : Reference threshold for space elements ('Codabar').

3.2.2.16 $RT_{s'}$: Reference threshold for space elements in characters with three wide bars ('Codabar').

3.2.2.17 RT_{2L} , RT_{2R} : RT_2 for character to left or right respectively of centre guard pattern ('EAN/UPC').

3.2.2.18 SL , SR : S for character to left or right respectively of centre guard pattern ('EAN/UPC').

3.2.2.19 V_1 , V_2 , V_3 , V_4 : Decodability values for certain symbologies.

3.2.2.20 W_b : Average wide bar width.

3.2.2.21 W_s : Average wide space width.

3.2.2.22 Z_b : Average narrow bar width.

3.2.2.23 Z_s : Average narrow space width.

4 Measurement methodology

4.1 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 on the bar code symbol in its final configuration whenever possible. 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 sampling plan defined in formal quality assurance procedures or by bilateral agreement, a suitable plan may be based on the recommendations in ISO 2859-1 : 1989 or ISO 3951 : 1989.

The application of the methodology described in this standard should not be the sole basis of a decision to accept or reject bar code symbols originated from bar code masters, provided that:

- a) the specifications of the masters have been derived from the correct evaluation of printability tests;
- b) the tests have been printed in accordance with defined procedures laid down in the application specification and intended to ensure the production of symbols of acceptable quality.

4.2 Correlation with traditional methodologies

Traditionally, two methodologies have been used to assess print quality in certain application standards. Advice is given in this standard to assist users, particularly producers of symbols, to correlate 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 (see 6.2);
- b) the calculation of a print contrast signal (PCS) value from the reflectance values R_L and R_D (see 6.3).

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

4.3 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 **4.3.4**.

The measured reflectance values shall be expressed as percentages of the reflectance of a barium sulfate or magnesium oxide reference sample complying with the requirements of ISO 7724-2 : 1984, which shall be taken as 100 percent. For equipment calibration purposes both a high-reflectance (light) and a low-reflectance (dark) calibration sample are required, the reflectances of which (as percentages of the reflectance of the reference sample) have been determined by methods traceable to the original reference standard.

4.3.1 Measurement wavelength(s)

All measurements shall be made using light of the wavelength(s) specified in the application specification. In the absence of such a 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 G for guidance on the selection of the wavelength of light.

4.3.2 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 (see **4.3.3**) at 45 degrees 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 shall be equivalent to the projected image of the sample area.

The measuring aperture diameter corresponds to that of the sample area to which it corresponds.

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

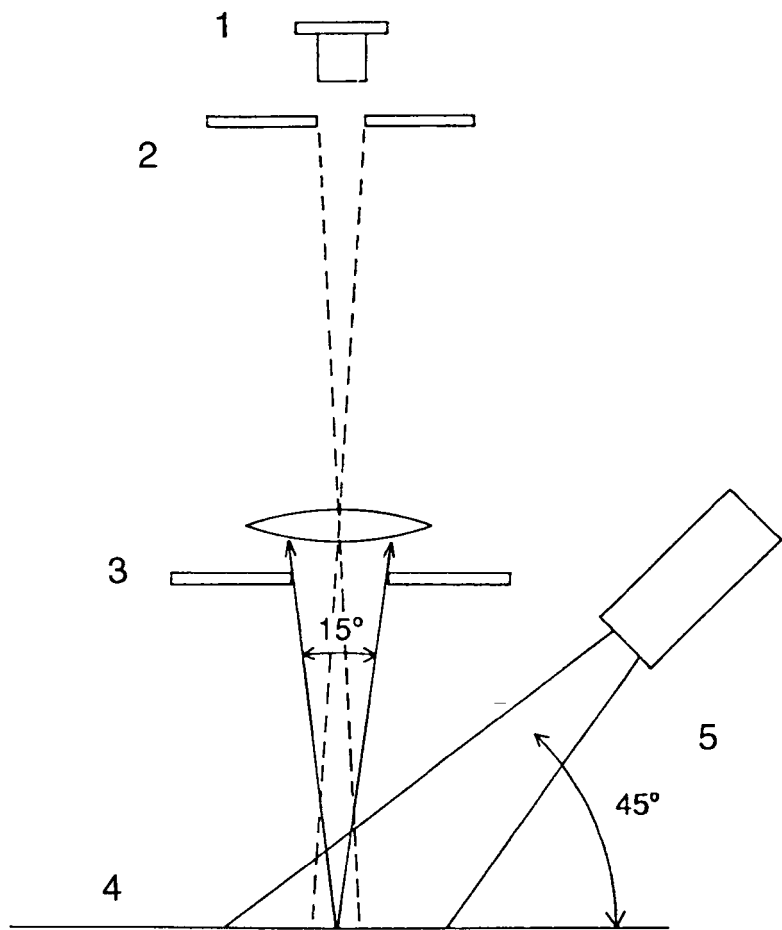
This reference geometry is intended to minimize the effects of specular reflection and to maximize those of diffuse reflection from the symbol. It may not correspond with the optical geometry of individual scanning systems. It is intended to provide a reference basis to assist the consistency of measurement.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

4.3.3 Sample area

The nominal diameter of the sample area should be specified by the user application specification, which should use the values given in table 1 as a guide. The sample area to be used should be equal in diameter to 0,8 times the smallest X dimension, or to the next smaller available aperture. Table 1 should be used as a guide where the measuring aperture diameter is not specified in the application specification. 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. It should be noted that for the measurement of EAN/UPC symbols, application specifications currently recommend the use of a sample area of 0,150 mm diameter (ref. no. 06).

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

The effective sample area 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.



- 1 Light sensing elements
- 2 Aperture at focus
- 3 Baffle
- 4 Sample
- 5 Light source

Figure 1. Reference optical arrangement

Table 1. Sample area diameter (measuring aperture)		
X Dimension mm	Sample area 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 sample area diameter in thousandths of an inch; this reference number is used for consistency with the ANSI standard X3.182.		

4.3.4 *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 shown 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 sample area diameter, whichever is greater. The inspection band shall extend to the full width of the symbol including quiet zones.

4.3.5 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, approximately equally spaced through the height of the inspection band. Refer to annex H 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 5.

4.3.6 Process control for repetitive printing

For purposes of process control of symbol production involving:

- repetitive printing of the same symbol from the same printing plate or similar material; and
- formal quality assurance procedures (which should conform with EN ISO 9000-1: 1994, EN ISO 9001 : 1994 and/or EN ISO 9002 : 1994), 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 in accordance with annex H, 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 4.1.

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 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.

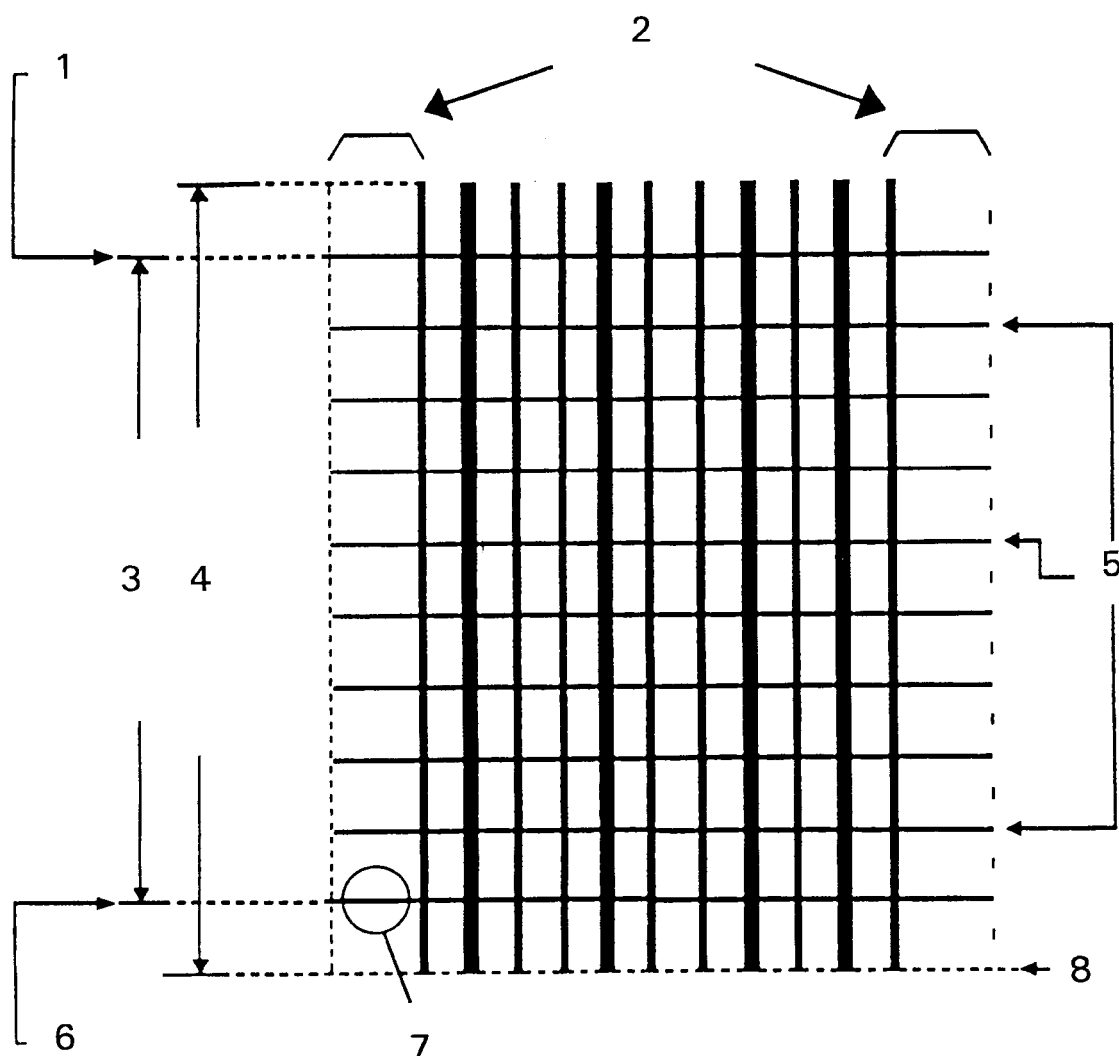
4.4 Scan reflectance profile

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.

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 profile can be determined by manual graphical analysis or automatically by numerical analysis. For example, the highest reflectance point on the profile in figure 3 is approximately 82 percent and the lowest is approximately 10 percent.

4.5 Profile assessment parameters

The following profile parameters shall be assessed for compliance with this standard. Clauses 4.5.1 to 4.5.7 describe each parameter. Figure 4 is the same profile as figure 3 with certain features indicated.



- 1 90 % of average bar height above average bar bottom edge
- 2 Quiet zones
- 3 Inspection band
- 4 Bar height
- 5 Scanning lines
- 6 10 % of average bar height above average bar bottom edge
- 7 Sample area
- 8 Average bar bottom edge

Figure 2. Inspection band