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Information technology — Automatic identification and data capture techniques — Bar code scanner and decoder performance testing

Technologies de l'information — Techniques d'identification automatique et de capture des données — Contrôle de scanner de code à barres et de performance du décodeur

Reference number
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Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. 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 document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 15423 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This first edition cancels and replaces ISO/IEC 15423-1:2001, which has been technically revised.

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Introduction

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

Bar code symbols can be produced with a wide variety of printing and other techniques, and the overall symbol dimensions can be uniformly scaled to suit particular requirements.

There is a wide range of bar code reading equipment using various scanning techniques, which enable bar code symbols to be read under many different conditions.

Bar code symbols may be a) “linear” i.e. read in a single dimension, where the height of the bars provides redundancy of information, or b) “two dimensional”, either in stacked rows to be read unidimensionally with multiple scans, or as a matrix of elements requiring two dimensional reading.

Bar code reading equipment must be capable of reliably converting the information represented as a bar code symbol into a form meaningful to the host computer system or otherwise to the user.

Manufacturers of bar code equipment, the producers of bar code symbols and the users of bar code technology require publicly available standard test specifications for bar code reading equipment to ensure the accuracy and consistency of performance of this equipment.

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Information technology — Automatic identification and data capture techniques — Bar code scanner and decoder performance testing

1 Scope

This International Standard defines the test equipment and procedures to be used to determine the performance of bar code scanning and decoding equipment. It deals with bar code scanning and decoding equipment both as integrated reading systems and as discrete units. It defines performance of the equipment in a particular configuration (e.g. a specific model) irrespective of the individual components used. It also defines in a normative annex operational parameters for the test equipment, and describes, in an informative annex, a means of classifying scanners.

2 Normative references

The following referenced documents are indispensable for the application 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 9001, *Quality management systems — Requirements*

ISO/IEC 15415, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Two-dimensional symbols*

ISO/IEC 15416, *Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Linear symbols*

ISO/IEC 15417, *Information technology — Automatic identification and data capture techniques — Bar code symbology specification — Code 128*

ISO/IEC 15424, *Information technology — Automatic identification and data capture techniques — Data Carrier Identifiers (including Symbology Identifiers)*

ISO/IEC 15426-1, *Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specifications — Part 1: Linear symbols*

ISO/IEC 15426-2, *Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specifications — Part 2: Two-dimensional verifiers*

ISO/IEC 15438, *Information technology — Automatic identification and data capture techniques — Bar code symbology specifications — PDF417*

ISO/IEC 16022, *Information technology — International symbology specification — Data matrix*

ISO/IEC 16388, *Information technology — Automatic identification and data capture techniques — Bar code symbology specification — Code 39*

ISO/IEC 19762 (all parts), *Information technology — Automatic identification and data capture techniques — Harmonized vocabulary*

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ITS/99-001, *International Symbology Specification — Reduced Space Symbology (RSS)* (AIM Inc.)

ITS/99-002, *International Symbology Specification — EAN.UCC Composite Symbology* (AIM Inc.)

NOTE The specification referenced ITS/99-001 will be superseded by ISO/IEC 24724, which is under development, and that referenced ITS/99-002 will be superseded by ISO/IEC 24723, which is also under development, on publication of the International Standards in question.

3 Terms and definitions

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

3.1
contact scanner
particular type of scanner in which the scanning action takes place with the scanner in actual or near contact with the symbol, e.g. wand or light pen

3.2
composite symbology
bar code symbol composed of both a linear bar code symbol and a two-dimensional bar code symbol

3.3
decode redundancy
acquisition of a predetermined number of identical decodes before acceptance by a decoder of a valid decode

EXAMPLE Decode redundancy of 2 requires two identical decodes.

3.4
exit window
datum point from which the reading diagram is measured, positioned on the beam midpoint and closest to the reading end of the scanner

3.5
maximum reading distance
distance from the exit window to the end of the depth of field

NOTE See R in Figure 2.

3.6
minimum reading distance
distance from the exit window to the beginning of the depth of field

NOTE See A in Figure 2.

3.7
raster
projection of a laser beam to create multiple, nearly parallel scan lines instead of a single line

3.8
raster distance
distance between the two most widely spaced adjacent scan lines projected on a plane at a defined distance from the scanner exit window

NOTE See E in Figure B.3.

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3.9
raster width
distance between the two outermost scan lines projected on a plane at a defined distance from the scanner exit window

NOTE This covers a reading field which depends on the construction of the scanner and on the reading distance. See D in Figure B.3.

3.10
reading angle
angular rotation of a symbol in an axis relative to a scan line

NOTE Three different reading angles, tilt, skew and pitch are illustrated in Figure 1. Tilt refers to rotation around the z axis, skew to rotation around the x axis and pitch to rotation around the y axis.

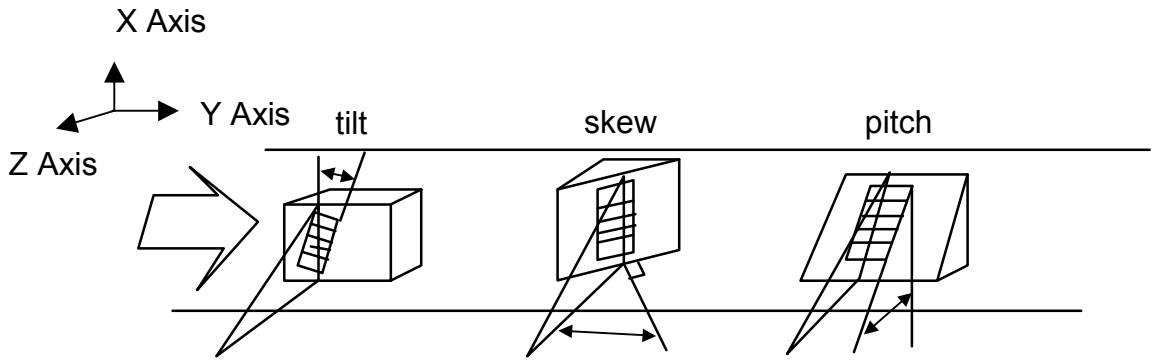


Figure 1 — Reading angles

3.11
reading diagram
graphical representation of the reading zone for a specific X dimension (or other parameters) of the bar code symbol

NOTE The parameters of the reading diagram are:

— measurements made from the exit window of the reader;

— reading distance, measured on the z axis;

— X dimension (in mm);

— skew, tilt and pitch angles;

— symbol contrast value;

— ambient light level; and

— symbology.

See Annex B.

3.12
reading zone
whole region (line, area or volume) in front of the exit window of a non-contact scanner in which defined symbols can be read

NOTE See zone MNOP in Figure 2.

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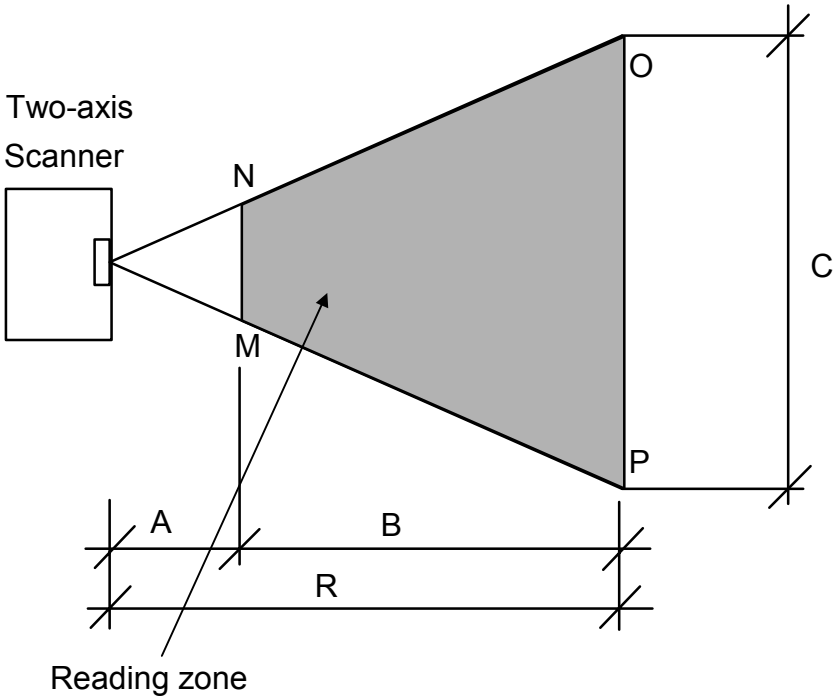


Figure 2 — Example of reading zone (MNOP)

NOTE Certain application requirements, for example in automated conveyor scanning systems, may restrict the effective reading zone to that shown in Figure 3 (MNO'P').

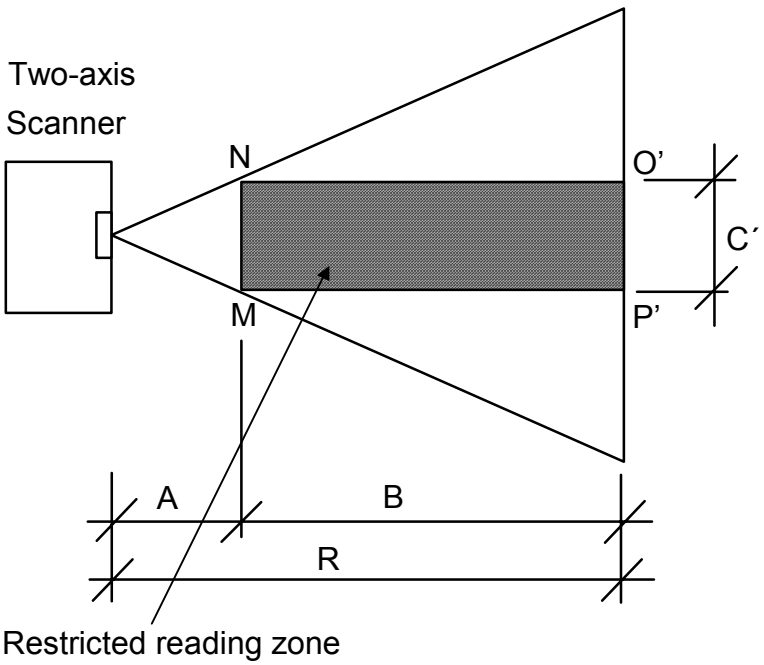


Figure 3 — Example of restricted reading zone (MNO'P')

3.13
read rate
percentage representing the number of good reads per 100 attempts to read a particular symbol

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3.14
resolution
width of the narrowest element capable of being read by the equipment under test

3.15
scan, noun
single pass of the scanning beam over the symbol or a portion of the symbol, or a single image capture with an image capture device

scan, verb
to pass the scanning beam over the symbol or a portion of the symbol, or to capture a single image with an image capture device

3.16
scan attempt
single pass of the scanner relative to the symbol (or vice versa), or a single activation of the scanner, e.g. triggering, for a period not exceeding two seconds or a time period specified by the manufacturer

3.17
scanning rate
number of times the bar code symbol is scanned per second, expressed in scans per second, or scan lines per second

3.18
scanning speed
speed at which the scanning spot of a scanner with a single axis reading diagram is passed across a bar code symbol

3.19
X axis
direction parallel to the motion of the scan beam, nominally perpendicular to the bars of a linear symbol

3.20
Y axis
direction perpendicular to the motion of the scan beam, nominally parallel to the bars of a linear symbol

3.21
Z axis
direction from the exit window to the symbol, nominally normal to the plane of the symbol

4 Abbreviations

Abbreviations:

CCD Charge Coupled Device.

CMOS Complementary Metal Oxide Semiconductor.

LED Light Emitting Diode.

5 Categories of scanning equipment

In order to enable the most appropriate set of tests for a given scanning device or unit to be selected, scanners are grouped for the purposes of this International Standard into three categories. The basis for this categorisation is the nature of the reading diagram applicable. Examples of various types of scanners are given in Annex B. Each category may be further subdivided into ‘continuously operating’ scanners, in which the scanning operation is already in progress when the symbol enters the reading zone, and ‘triggered’ scanners, where the symbol is already in the reading zone when the scanning operation is initiated.

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5.1 Scanners with single-axis reading diagram

These are defined as scanners with a reading diagram which extends as a single line from the exit window of the scanner to the maximum reading distance along the z axis. The scanning action therefore has to be created by moving either the scanner or the symbol relative to the other in a direction nominally perpendicular to the height of the bars.

The reading diagram for such scanners can be represented as a single line extending outwards from the exit window of the scanner. See Figure B.1.

5.2 Scanners with two-axis reading diagram

These are defined as scanners with a reading diagram which extends in a single plane from the exit window of the scanner to the maximum reading distance along the z axis and perpendicularly in both directions along the x axis. The scanning action is created either by sweeping the scanner beam across the symbol in a direction nominally perpendicular to the height of the bars, or by electronically sampling in turn individual elements of a photosensitive array on which an image of the bar code symbol is focussed.

The reading diagram for such scanners can be represented in a two-dimensional form. See Figure B.2.

5.3 Scanners with three-axis reading diagram

These are defined as scanners with a reading diagram which extends from the exit window of the scanner to the maximum reading distance along the z axis, and perpendicularly to this in both directions along the x and y axes which are also perpendicular to each other.

The reading diagram for such scanners is the representation of a three-dimensional solid.

5.3.1 Multi-line Scanners

The scanning action is created either by sweeping the scanner beam across the symbol in a series of nominally parallel scans in a direction nominally perpendicular to the height of the bars, see Figure B.3 or in a pattern of scan lines at various angles, or multi-window scanners, see Figure B.5.

5.3.2 Image Scanners

The scanning action is created by electronically sampling in turn individual photosensitive elements of an area array on which an image of the bar code symbol is focussed; see Figure B.4.

6 Test requirements

6.1 Test methods

Manufacturers' test procedures should be in accordance with the requirements of ISO 9001.

Tests should wherever possible be carried out on a complete reading system comprising both scanner and decoder.

Where it is required to report the performance of a scanner or a decoder independently, the unit shall be tested in conjunction with one or more representative decoder or scanner unit(s) respectively, but only the parameters relative to scanning or decoding performance, as applicable, shall be reported. The decoder or scanner units used shall be reported with the test results.

Manufacturers may optionally test scanner or decoder performance independently using the equipment defined in 6.5.4.1 or 6.5.4.2 but it should be noted that the results may not correspond exactly to those obtained when tested as a complete system.

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6.2 Selection of equipment for testing

Tests shall be carried out on at least one unit which has been selected from a production batch in accordance with the manufacturer's quality control sampling scheme.

NOTE It is in the manufacturer's interest to ensure that the unit selected is representative of its type. Guidance on sampling is given in ISO 2859-1.

6.3 Test conditions

6.3.1 Environment

Tests shall be conducted under manufacturer-specified environmental conditions (power supply, temperature, relative humidity and ambient light conditions) and the test conditions shall be recorded as part of the test report.

Test charts to be used shall have been stored under the temperature and humidity conditions specified for a sufficient time to ensure their dimensional stability during the test period.

6.3.2 Equipment configuration

The following information on the installation of the equipment under test shall be recorded:

— description of configuration, including type/model of scanner and decoder, and other Physical conditions, e.g. type of interface, etc.;

— logical conditions such as the type of output by the scanner, or sent to the decoder e.g. analogue waveform, digital output (where a scanner or decoder is being tested rather than a complete reader).

6.4 Test Charts

Test charts should be produced on dimensionally stable materials with image characteristics which are consistent within the image or symbol area used for the test. As an example, Kodak Kodagraph Continuous Tone White Film (CTW7) is one material that has been found to be suitable when backed with a black opaque material to minimize the effects of show-through.

When equipment which is unable to process any of the symbologies in the test charts is to be tested, an equivalent set of test symbols in another appropriate symbology should be used. When other symbologies are being used, certain parameters may require to be modified to comply with the parameters of the symbology specification, e.g. row height or wide-to-narrow ratio.

When selecting materials for this use it is important to consider:

— high dimensional stability

— high substrate opacity (minimized show-through)

— high consistency of substrate surface reflectance

— bars (regions of low reflectivity) should appear black and have a low reflectivity over the entire visible portion of the spectrum

— space (regions of high reflectivity) should appear white and have a high reflectivity over the entire visible portion of the spectrum

— high consistency of image reflectance

— high image sharpness (edge definition or acuity)

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— surface finish (low gloss with low surface roughness)

— broad range of achievable image reflectance (continuous tone).

Manufacturers may extend the range of symbol parameter values (e.g. X dimension) beyond those specified. Test charts with other symbologies may be produced for testing using data messages that result in similar size symbols as the test charts of the most similar symbology type.

6.4.1 Test Charts for linear symbologies

A set of bar code test charts is defined, which shall be used for the tests indicated in the following sections. Test charts shall be measured in accordance with ISO/IEC 15416, using a verifier complying with ISO/IEC 15426-1, and shall achieve overall symbol grade 3,5 or better (in the case of test chart no. 2 the grades for symbol contrast and edge contrast shall be ignored and an overall grade shall be calculated based on remaining parameters). Measuring apertures shall be in accordance with Table 1 of ISO/IEC 15416. Decodability values for the test symbols shall be not less than 0,80. Additionally, the Z dimension shall be measured and shall be within the tolerances specified for the test chart in question. Symbols shall comply with ISO/IEC 15417 or ISO/IEC 16388. When measured with a light source of the same wavelength as that of the scanner under test, the reflectance and symbol contrast values of the test charts shall be as specified below. The measured quiet zones shall be the minimum width defined by the symbology specification (with tolerances of +1Z, -0Z), and the outer boundary of each quiet zone shall be indicated by a vertical bar. This bar shall be at least 10Z wide and shall have a maximum reflectance no greater than $[R_{min} + \max(R_D)] / 2$, where R_{min} and R_D are as defined in ISO/IEC 15416.

TEST CHART no. 1 – Resolution, scanning speed, reading diagram, reading angles, lateral motion

This chart comprises two sets of symbols, one in each symbology, with a range of values of the X dimension and with a Y dimension equal to 1,5 times the symbol width.

Table 1 — Parameters for Test Chart no. 1

Parameter	Value
Symbology	Code 39 and Code 128
X dimension	From 0,10 mm to 0,50 mm in steps of 0,05 mm
Step tolerance	± 0,01mm., i.e. the maximum value of Z is (X + 0,01 mm) and the minimum value of Z is (X - 0,01 mm).
Element width tolerance	± 0,05Z
Average bar width tolerance	± 0,02Z
Y dimension	1,5 times symbol width (excluding quiet zones)
Wide:narrow ratio	3:1 in the case of Code 39 or other two width symbologies
R_{max}	85% ± 5%
R_{min}	3% ± 3%
Symbol content	6 symbol characters including start, mandatory check characters, and stop. The recommended data for Code 39 is “ABCD” and for Code 128 it is “ABC”.

NOTE R_{max} and R_{min} are as defined in ISO/IEC 15416.

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TEST CHART no. 2 – Symbol Contrast

This group of charts comprises two sets of symbols, one in each symbology, each with two values of X dimension and, for each value of X, with nine different nominal values of symbol contrast as shown in Table 3 below. The tolerance on symbol contrast shall be ± 4 percentage points and this will limit the combined effect of the individual dark or light reflectance tolerances. The values of symbol contrast, R_{max} and R_{min} shall be measured using a light source of 660 nanometres peak wavelength and stated on the Test Charts. Values of symbol contrast when measured at 633 nanometres and 900 nanometres with the same apertures shall also be stated on the Test Charts. The measurement geometry shall be as defined in ISO/IEC 15416.

Table 2 — Parameters for Test Chart no. 2

Parameter	Value
Symbology	Code 39 and Code 128
X dimension	0,20 mm and 0,40 mm
Element width tolerance	± 0,05Z
Average bar width tolerance	± 0,02Z
Y dimension	20 mm
Wide:narrow ratio	3:1 in the case of Code 39 or other two width symbologies
Symbol contrast	as per Table 3 below
Symbol contrast tolerance	± 4 percentage points
R_{max} and R_{min}	as per Table 3 below
R_{max} and R_{min} tolerances	± 4 percentage points but subject to overriding symbol contrast tolerance
Symbol content	6 symbol characters including start, mandatory check characters, and stop. The recommended data for Code 39 is “ABCD” and for Code 128 it is “ABC”.

Table 3 — Symbol contrast

Nominal Symbol Contrast	R_{max}	R_{min}	ISO/IEC 15416 Symbol Contrast grade
47%	80%	33%	2
30%	80%	50%	1
25%	80%	55%	1
20%	80%	60%	1
47%	57%	10%	2
25%	35%	10%	1
20%	30%	10%	1
15%	25%	10%	0
10%	20%	10%	0

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6.4.2 Test charts for multi-row and composite symbols

6.4.2.1 PDF417

A set of PDF417 test charts defined in Table 4 shall be used.

Test charts shall be measured in accordance with ISO/IEC 15415 and ISO/IEC 15438, using a verifier complying with ISO/IEC 15426 and shall achieve overall symbol grade 3,5 or better (in the case of test chart no. 4 the grades for symbol contrast and edge contrast shall be ignored and an overall grade shall be calculated based on remaining parameters). Measuring apertures shall be in accordance with ISO/IEC 15415. Decodability values for the test symbols shall be not less than 0,8. Additionally, the X dimension shall be measured and shall be within the tolerances specified for the test chart in question. Symbols shall comply with the ISO/IEC 15438 symbology specification. Manufacturers may extend the range of symbol parameter values (e.g. X dimension) beyond those specified.

When measured with a light source of the same wavelength as that of the scanner under test, the reflectance and symbol contrast values of the test charts shall be as specified below. The measured quiet zones shall be the minimum width defined by the symbology specification.

TEST CHART no. 3 – PDF417 resolution, reading diagram, reading angles, ambient illumination and sensitivity.

This chart comprises high contrast symbols with a range of values of the X dimension

Table 4 — Parameters for Test Chart no. 3

Parameter	Value
Symbology	PDF417
Error correction level	3
X-dimension	0,10 mm to 0,50 mm in steps of 0,05 mm
Step tolerance	± 0,01 mm, i.e. the maximum value of Z is (X + 0,01 mm) and the minimum value of Z is (X - 0,01 mm).
Element width tolerance	± 0,05Z
Average element width tolerance	± 0,02Z
Y dimension or row height	3X
Symbol format	12 rows by three data columns
R_{max}	85% ± 5%
R_{min}	3% ± 3%
Symbol content	$[)>{}^{R}{}_{S}06{}^{G}{}_{S}12V043325711{}^{G}{}_{S}1P123456{}^{R}{}_{S}\ {}^{E}O_{T}$

NOTE R_{max} and R_{min} are as defined in ISO/IEC 15415.

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TEST CHART no. 4 – PDF417 Symbol Contrast

This group of charts comprises a set of symbols, with two values of X dimension and, for each value of X, with nine different nominal values of symbol contrast as shown in Table 5 and Table 3. The tolerance on symbol contrast shall be ± 4 percentage points and this will limit the combined effect of the individual dark or light reflectance tolerances. The values of symbol contrast, R_{max} and R_{min} shall be measured using a light source of 660 nanometers peak wavelength and stated on the Test Charts. Values of symbol contrast measured at 633 nanometers shall also be stated on the Test Charts. The measurement geometry shall be as defined in ISO/IEC 15415.

Table 5 — Parameters for Test Chart no. 4

Parameter	Value
Symbology	PDF417
Error correction level	3
X-dimension	0,20 mm and 0,40 mm
Element width tolerance	± 0,05Z
Average element width tolerance	± 0,02Z
Y dimension or row height	3X
Symbol format	12 rows by three data columns
Symbol contrast	as per Table 3
Symbol contrast tolerance	± 4 percentage points
R_{max} and R_{min}	as per Table 3
R_{max} and R_{min} tolerances	± 4 percentage points but subject to overriding symbol contrast tolerance
Symbol content	$[)>^{R}_{S}06^{G}_{S}12V043325711^{G}_{S}1P123456^{R}_{S}\ ^{E}O_{T}$

6.4.2.2 Composite symbology RSS-14 Composite (with CC-A)

A set of RSS-14 Composite test charts in accordance with AIM ITS/99-001 and AIM ITS/99-002 defined in Table 6 shall be used.

Test charts shall be measured in accordance with ISO/IEC 15415, using a verifier complying with ISO/IEC 15426 and shall achieve overall symbol grade 3,5 or better (in the case of test chart no. 6 the grades for symbol contrast and edge contrast shall be ignored and an overall grade shall be calculated based on the remaining parameters). Measuring apertures shall be in accordance with ISO/IEC 15415. Decodability values for the test symbols shall be not less than 0,8. Additionally, the X dimension shall be measured and shall be within the tolerances specified for the test chart in question. Symbols shall comply with the appropriate symbology specifications.

When measured with a light source of the same wavelength as that of the scanner under test, the reflectance and symbol contrast values of the test charts shall be as specified below. The measured quiet zones shall be the minimum width defined by the symbology specification.

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TEST CHART no. 5 – RSS-14 Composite Resolution, reading diagram, reading angles, ambient illumination and lateral motion sensitivity.

This chart comprises high contrast symbols with a range of values of the X dimension

Table 6 — Parameters for Test Chart no. 5

Parameter	Value
Symbology	RSS-14 Composite (with CC-A)
X-dimension	From 0,10 mm to 0,50 mm in steps of 0,05 mm
Step tolerance	± 0,01mm., i.e. the maximum value of Z is (X + 0,01 mm) and the minimum value of Z is (X - 0,01 mm).
Element width tolerance	± 0,05Z
Average element width tolerance	± 0,02Z
Y dimension	2X for 2D Composite Component 33X for the Linear Component
R_{max}	85% ± 5%
R_{min}	3% ± 3%
Symbol content	RSS-14 data: 00614141012343 CC-A data: 1701120110ABC123456

NOTE R_{max} and R_{min} are as defined in ISO/IEC 15415.

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TEST CHART no. 6 – RSS-14 Composite (with CC-A) Symbol Contrast

This group of charts comprises a set of symbols, with two values of X dimension and, for each value of X, with nine different nominal values of symbol contrast as shown in Table 7 and Table 3. The tolerance on symbol contrast shall be ± 4 percentage points and this will limit the combined effect of the individual dark or light reflectance tolerances. The values of symbol contrast, R_{max} and R_{min} shall be measured using a light source of 660 nanometers peak wavelength and stated on the Test Charts. Values of symbol contrast measured at 633 nanometers shall also be stated on the Test Charts. The measurement geometry shall be as defined in ISO/IEC 15415.

Table 7 — Parameters for Test Chart no. 6

Parameter	Value
Symbology	RSS-14 Composite (with CC-A)
X-dimension	0,20 mm and 0,40 mm
Element width tolerance	± 0,05Z
Average element width tolerance	± 0,02Z
Y dimension	2X for 2D Composite Component 33X for the Linear Component
Symbol contrast	as per Table 3
Symbol contrast tolerance	± 4 percentage points
R_{max} and R_{min}	as per Table 3
R_{max} and R_{min} tolerances	± 4 percentage points but subject to overriding symbol contrast tolerance
Symbol content	RSS-14 data: 00614141012343 CC-A data: 1701120110ABC123456

6.4.3 Test charts – 2D matrix symbols – Data Matrix

A set of Data Matrix test charts in accordance with ISO/IEC 16022 and as defined in Table 8 shall be used.

Test charts shall be measured in accordance with ISO/IEC 15415, using a verifier complying with ISO/IEC 15426 and shall achieve overall symbol grade 3,5 or better (in the case of test chart no. 8 the grades for symbol contrast shall be ignored and an overall grade shall be calculated based on the remaining parameters). Measuring apertures shall be in accordance with ISO/IEC 15415 Additionally, the X dimension shall be measured and shall be within the tolerances specified for the test chart in question. Symbols shall comply with ISO/IEC 16022.

When measured with a light source of the same wavelength as that of the scanner under test, the reflectance and symbol contrast values of the test charts shall be as specified below. The measured quiet zones shall be the minimum width defined by the symbology specification.

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TEST CHART no. 7 – Data Matrix Resolution, reading diagram, reading angles, ambient illumination and lateral motion sensitivity.

This chart comprises high contrast symbols with a range of values of the X dimension

Table 8 — Parameters for Test Chart no. 7

Parameter	Value
Symbology	Data Matrix ECC 200
X-dimension	0,10 mm to 0,50 mm in steps of 0,05 mm
Step tolerance	± 0,01 mm., i.e. the maximum value of Z is (X + 0,01 mm) and the minimum value of Z is (X - 0,01 mm).
Module dimensional tolerance	± 0,05Z
Average module dimensional tolerance	± 0,02Z
R_{max}	85% ± 5%
R_{min}	3% ± 3%
Symbol content	[)>$^{R}_{S}$06$^{G}_{S}$12V043325711$^{G}_{S}$1P123456$^{R}_{S}$ $^{E}O_{T}$

NOTE R_{max} and R_{min} are as defined in ISO/IEC 15415.

TEST CHART no. 8 – Data Matrix Symbol Contrast

This group of charts comprises a set of symbols, with two values of X dimension and, for each value of X, with nine different nominal values of symbol contrast as shown in Table 9 and Table 3. The tolerance on symbol contrast shall be ± 4 percentage points and this will limit the combined effect of the individual dark or light reflectance tolerances. The values of symbol contrast, R_{max} and R_{min} shall be measured using a light source of 660 nanometers peak wavelength and stated on the Test Charts. Values of symbol contrast measured at 633 nanometers shall also be stated on the Test Charts. The measurement geometry shall be as defined in ISO/IEC 15415.

Table 9 — Parameters for Test Chart no. 8

Parameter	Value
Symbology	Data Matrix ECC 200
X-dimension	0,20 mm and 0,40 mm
Module width tolerance	± 0,05Z
Average module width tolerance	± 0,02Z
Symbol contrast	as per Table 3
Symbol contrast tolerance	± 4 percentage points
R_{max} and R_{min}	as per Table 3
R_{max} and R_{min} tolerances	± 4 percentage points but subject to overriding symbol contrast tolerance
Symbol content	[)>$^{R}_{S}$06$^{G}_{S}$12V043325711$^{G}_{S}$1P123456$^{R}_{S}$ $^{E}O_{T}$

NOTE R_{max} and R_{min} are as defined in ISO/IEC 15415.

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6.5 Test equipment

The accuracy and resolution of test equipment shall be appropriate for the measurements being performed, and shall be recorded.

6.5.1 Test equipment for scanners with single axis reading diagram

a) A rotating drum of 60 mm diameter (or greater), or a support capable of linear movement, as appropriate to the physical construction of the scanner, to which the test symbol or scanner under test can be affixed with the bar height perpendicular to the direction of rotation or movement, together with means of measuring the speed of the symbol relative to the scanner.

b) A means of supporting the scanner or the test symbol to ensure that the scanning beam passes through the symbol, together with means of varying and measuring the skew angle of the scanning beam relative to a plane tangential to the surface of the symbol at the point where the scanning beam meets the symbol, and of varying and measuring the distance between the scanner exit window and the symbol.

6.5.2 Test equipment for scanners with two axis reading diagram

A support capable of movement in two axes of the plane containing the scanning beam of the scanner, to which a test symbol can be affixed perpendicular to the central axis of the plane and with the bar height perpendicular to the plane and passing through it, together with means of measuring the position and angle of the symbol in two dimensions relative to the scanner exit window.

6.5.3 Test equipment for scanners with three axis reading diagram

Equipment similar to that defined in 6.5.2 but capable of movement in three axes, together with means of measuring the position and angle of the test symbol in three dimensions relative to the scanner exit window.

6.5.4 Additional test equipment

6.5.4.1 Test equipment for testing a scanner independently of a decoder

In order to test a scanner independently of a decoder, an oscilloscope connected to display the digital signal from the scanner, and means of recording and analysis of the widths of the individual pulses in the signal in appropriate time units are required.

6.5.4.2 Test equipment for testing a decoder independently of a scanner

In order to test a decoder independently of a scanner, a signal generator is required. The output from the signal generator shall emulate the bar/space pattern of a correctly encoded bar code symbol. The emulation shall comply with the specification of the symbology under test. The data represented in the pulse string(s) should cover the complete character set of the symbology and enable the decoder's processing of optional features of the symbology to be tested. The electrical characteristics of the pulse string shall be adapted to the interface requirements of the decoder as specified by the manufacturer. Auxiliary equipment which will enable the data output by the decoder to be ascertained is also required.

6.5.5 Test equipment for complete reading systems

Complete reading systems shall be tested using the equipment specified in 6.5.1 to 6.5.4 as appropriate for the type of scanner together with auxiliary equipment which will enable the data output from the reading system to be ascertained.

6.6 Test criteria

The test criteria to be applied in order to decide whether or not a test symbol has been successfully scanned or read are defined below. Where complete reading systems comprising both scanner and decoder units are

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to be tested, the condition defined in 6.6.1 shall apply. Where scanner units are to be tested without a decoder, the condition defined in 6.6.2 shall apply. Where decoder units are to be tested, the condition defined in 6.6.1 shall apply.

6.6.1 Test criterion for complete reading systems and decoders

The test criterion is met if the read rate equals or exceeds 80% based on a minimum of 10 scan attempts. Any misreads shall be noted and are grounds for rejecting the system for the conditions tested.

6.6.2 Test criterion for scanners

The test principle is based on the extent to which the Z module is distorted when measured at the scanner digital output. An appropriate test bar code symbol is fixed on the test equipment with the bar height perpendicular to the direction of movement or to the scan line. The Z dimension used shall be reported with the results of the test.

An oscilloscope is connected to the digital output of the scanner to enable the widths of the pulses corresponding to individual elements of the symbol to be measured in appropriate time units.

For each symbol character:

a) measure the overall scan duration of the character;

b) measure the scan duration of each bar and space element of the character;

c) using these time measurements, compute the decodability measure and grade for that symbol character, using the method specified in ISO/IEC 15416. Each character must receive a grade of 2,0 or better for this scan pass.

Annex C contains a hypothetical example, using the nomenclature of ISO/IEC 15416, and based on a Code 128 symbol character.

6.7 Parameters to be tested and test methods

Table 10 shows the parameters to be tested for each category of scanner.

Table 10 — Parameters to be tested for various categories of scanner

Parameter	single axis	two axis	three axis
Resolution	x	x	x
Scanning Speed	x		
Lateral Motion		x	x
Reading Diagram	x	x	x
Ambient Illumination	x	x	x
Tilt	x	x	x
Pitch	x	x	x
Skew	x	x	x

The tests are described in more detail in the following sections.

It should be noted that these parameters are interdependent to varying degrees, e.g. resolution and scanning speed, depth of field and symbol contrast, and the test results should record the values of all relevant variables.

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6.7.1 Scanners with single axis reading diagram

6.7.1.1 Resolution

This test is designed to report the minimum element width capable of being resolved by the equipment under test. The test equipment described in 6.5.1 shall be used. The scanner shall be mounted so as to ensure that tilt and pitch angles shall be 0° ± 2°. The skew angle shall be such as to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 1, with a set of Z dimensions from 0,50 mm to 0,10 mm (or other values appropriate to the equipment under test) shall be used.

a) The test symbol with the highest Z value is fixed on the test equipment with the bar height perpendicular to the direction of movement so that the axis of the scanner exit window will pass through the midpoint of the bar height.

b) The distance “d” between scanner exit window and symbol shall be adjusted to a minimum.

c) The test equipment is set in motion at a speed corresponding to the conditions of use for which the scanner is intended.

d) If the test criterion in 6.6 is not met, then the distance “d” is progressively increased until the test criterion is met; if it is not met at all before the distance “d” has reached a value substantially exceeding the likely conditions of use of the scanner, the test is repeated from step a) using the test symbol with the next lower Z value.

e) If the test criterion in 6.6 is met, the test is repeated from step a) using the test symbol with the next lower Z value.

f) The resolution of the scanner is defined as the Z dimension of the test symbol with the lowest Z value for which the criterion in 6.6 is met.

The test results should report the resolution in mm, the skew angle, and record the minimum distance “d” at which the test criterion is met with the test symbol with the Z value equal to the resolution of the scanner.

6.7.1.2 Scanning Speed

This test is designed to report the minimum and maximum scanning speeds of the equipment. The test equipment described in 6.5.1 shall be used and shall be set up as described in 6.7.1.1. A test bar code symbol from test chart no. 1 with a Z dimension equal to or greater than the resolution of the equipment shall be used. The Z dimension used shall be reported with the result of the test.

a) The test bar code symbol is fixed on the test equipment with the bar height perpendicular to the direction of movement so that the axis of the scanner exit window will pass through the midpoint of the bar height.

b) The distance “d” between scanner and symbol shall be adjusted to be equal to that recorded with the result of the resolution test in 6.7.1.1 above.

c) The test equipment is set in motion and its speed is varied as necessary in order to determine the minimum and maximum speeds at which the test criterion in 6.6 is met.

The test results should report minimum and maximum scanning speeds in mm/s. and should record the Z dimension of the test symbol used, the skew angle and the distance “d”.

6.7.1.3 Reading diagram

This test is designed to determine the maximum and minimum reading distances and depth of field of the equipment under test. The test equipment described in 6.5.1 shall be used and shall be set up as described in 6.7.1.1. A reading diagram shall be determined using each of three or more test bar code symbols from test

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chart no. 1 with different values of measured nominal dimension. The lowest Z dimension shall be equal to the resolution of the scanner from 6.7.1.1, the largest Z dimension shall be as specified by the manufacturer, and that of the third and subsequent symbols shall be approximately evenly spaced between the first two. The Z dimensions used shall be reported with the result of the test.

For each symbol:

a) The test symbol is fixed on the test equipment with the bar height perpendicular to the direction of movement so that the axis of the scanner exit window will pass through the midpoint of the bar height.

b) The distance “d” between scanner and symbol shall be adjusted to a minimum.

c) The scanner is activated and the test equipment set in motion at a speed within the range determined in accordance with 6.7.1.2.

d) If the test criterion in 6.6 is not met, then the distance “d” is progressively increased to the value d1 at which the test criterion is first met.

e) The distance d1 corresponds to the minimum reading distance of the equipment.

f) The distance “d” is then progressively increased to the highest value, d2, at which the test criterion is still met.

g) The distance d2 corresponds to the maximum reading distance of the equipment.

The test results should report, for each Z dimension used for the test, the minimum and maximum reading distances and the depth of field as the difference between these reading distances in mm; the reading diagram should represent the limits of the reading zone.

Note that additional reading diagrams should be determined for different values of symbol contrast using test symbols from test chart no. 2, and may be determined for variations in other parameters such as reading angles etc. and the values of such variables should be recorded with the test results.

6.7.1.4 Symbol contrast

This test is designed to report the minimum values of symbol contrast at which the equipment under test can read. The test equipment described in 6.5.1 shall be used. The scanner shall be mounted so as to ensure that tilt and pitch angles shall be $0° \pm 2°$. The skew angle shall be such as to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 2, with the Z dimension closest to 1,5 times the resolution of the equipment as determined in 6.7.1.1 shall be used. The test shall be performed twice, first with the subset of test symbols with decreasing values of R_{max} and next with the subset of test symbols with increasing values of R_{min}.

a) The test symbol with the highest symbol contrast value is fixed on the test equipment with the bar height perpendicular to the direction of movement so that the axis of the scanner exit window will pass through the midpoint of the bar height.

b) The distance “d” between scanner exit window and symbol shall be adjusted to the midpoint between the minimum and maximum reading distances for the Z dimension in use, as determined in 6.7.1.3.

c) The test equipment is set in motion at a speed corresponding to the conditions of use for which the scanner is intended.

d) If the test criterion in 6.6 is met, then the test is repeated from step a) using test symbols with decreasing symbol contrast values to determine the lowest value of SC for which the test criterion in 6.6 can be met.

The test results should report the lowest symbol contrast value, the Z dimension, the skew angle, and record the distance “d” at which the test measurements were made. If different results are obtained with the two subsets of test symbols, both values of minimum symbol contrast shall be stated together with the corresponding values of R_{max} and R_{min}.

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6.7.1.5 Ambient illumination

This test is used to determine the ambient light levels under which the scanner will operate.

In order to determine the effect of ambient illumination on the read rate. Use the Test chart no. 1 with a X-dimension set to 1,5 times the resolution as determined in section 6.7.1.1. Place this test chart at the mid point of the appropriate reading diagram as determined in section 6.7.1.3. The scanner shall be mounted so as to ensure that tilt and pitch angles shall be 0° ± 2°. Nominally the skew angle shall be set at 0° ± 2°, however, if required, the skew angle shall be adjusted to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. The light source is to be a high temperature halogen lamp with a color temperature of 3 000°K ± 500°K. Position the light source at a 45 degree incidence to the test chart. Specific applications may not require the extended range noted in Table 11.

Table 11 — Ambient illumination levels

Lighting Conditions	Illumination Level Lux
Dark room	0
Desk top	100
Overcast daylight	1,000
Bright sunlight	100,000

a) Place the equipment described in 6.5.1 in a darkened area.

b) Set the test equipment in motion at a speed midway in the range determined in 6.7.1.2.

c) Activate the scanner.

d) Record whether the test criterion in 6.6 is met.

e) Repeat the test with the next higher level of ambient illumination.

The test results should report the Z dimension, skew angle, distance, scan velocity and ambient illumination levels at which the test criterion is satisfied.

6.7.1.6 Reading angles

This test is designed to report the minimum and maximum value of the three parameters, tilt, pitch and skew. The test shall be performed for each of the parameters individually while holding the other two constant at their initial values as defined under step a). The test equipment described in 6.5.1 shall be used and shall be set up as described in 6.7.1.1. The equipment under test is fixed mounted in a position so that the test symbol is on the axis of the scanning beam at a distance “d” from the exit window midway between the minimum and maximum reading distances. A test bar code symbol from test chart no. 1 with a Z dimension equal to or greater than the resolution of the equipment is used.

a) The test bar code symbol shall initially be fixed on the test equipment at a tilt angle of 0° (i.e. with the height of the bars perpendicular to the direction of movement) and pitch and skew angles of 0° or depending on which is being tested the lowest angle required to avoid specular reflection.

b) The test equipment is set in motion at a speed within the range determined in accordance with 6.7.1.2.

c) The relative angle of the test bar code symbol with respect to the scanner is progressively varied in steps of 5° (or smaller steps if appropriate) around the axis corresponding to the reading angle under test until the lowest and highest rotations at which the test criterion in 6.6 is met have been determined.

The test results should report, for each parameter, the minimum and maximum angles, together with the Z dimension of the test symbol.

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6.7.2 Scanners with two axis reading diagram

The following test are performed on the symbols from test sheets for both linear and multi-row symbologies. The test results should be recorded separately for each symbology used in the tests.

6.7.2.1 Resolution

This test is designed to report the minimum element width capable of being resolved by the equipment under test. The test equipment described in 6.5.2 shall be used. The scanner and symbol shall be mounted so as to ensure that tilt and pitch angles shall be 0°, ± 2°. The skew angle is chosen to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 1, test chart no. 3 and test chart no. 5, with a set of Z dimensions from 0,50 mm to 0,10 mm (or other values appropriate to the equipment under test) shall be used.

a) The test symbol with the highest Z value is fixed on the test equipment with the bar height perpendicular to the scan line of the scanner and with its midpoint on the axis of the scanner exit window.

b) The distance “d” between scanner exit window and symbol shall be adjusted to a minimum.

c) The scanner is activated.

d) If the test criterion in 6.6 is not met, then the distance “d” is progressively increased until the test criterion is met; if it is not met at all before the distance “d” has reached a value substantially exceeding the likely conditions of use of the scanner, the test is repeated from step a) using the test symbol with the next lower Z value.

e) If the test criterion in 6.6 is met, the test is repeated from step a) using the test symbol with the next lower Z value.

f) The resolution of the scanner is defined as the “Z” dimension of the test symbol with the lowest Z value for which the criterion in 6.6 is met.

The test results should report the resolution in mm. and record the minimum distance “d” at which the test criterion is met with the test symbol with the Z value equal to the resolution of the scanner.

6.7.2.2 Reading Diagram

This test is designed to determine the maximum and minimum reading distances, depth of field and the boundaries of the reading zone of the equipment under test. The test equipment described in 6.5.2 shall be used and shall be set up as described in 6.7.1.1. A reading diagram shall be determined using each of three or more test bar code symbols from test chart no. 1, test chart no. 3 and test chart no. 5, with different values of measured nominal dimension. The lowest Z dimension shall be equal to the resolution of the scanner from 6.7.2.1, the largest Z dimension shall be as specified by the manufacturer, and that of the third and subsequent symbols shall be approximately evenly spaced between the first two. The Z dimensions used shall be reported with the result of the test.

For each symbol:

a) The test symbol is fixed on the test equipment with the bar height perpendicular to the scan line of the scanner and with its midpoint on the axis of the scanner exit window.

b) The distance “d” between scanner and symbol shall be adjusted to a minimum.

c) The scanner is activated.

d) If the test criterion in 6.6 is not met, then the distance “d” is progressively increased to the value d1 at which the test criterion is first met.

e) The distance d1 corresponds to the minimum reading distance of the equipment.

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f) The test symbol is moved laterally in each direction perpendicular to the central axis of the scanning pattern, to determine the farthest points at which the test criterion is still met. The boundary of the reading diagram at these points is defined as the outer edge of the quiet zone of the test symbol farther from the central axis of the scanning pattern.

g) The test symbol is then returned to the position defined in step a).

h) The distance "d" is then progressively increased to the highest value, d2, at which the test criterion is still met.

i) The distance d2 corresponds to the maximum reading distance of the equipment.

j) Step f) is repeated at distance d2.

k) Step f) should be repeated at distances intermediate between d1 and d2 to determine the boundaries of the reading zone more fully.

The test results should report, for each Z dimension used for the test, the minimum and maximum reading distances and the depth of field as the difference between these reading distances in mm; the reading diagram should represent the boundaries of the reading zone.

Note that additional reading diagrams should be determined for different values of symbol contrast using test symbols from test chart no. 2, test chart no. 4 and test chart no. 6, and may be determined for variations in parameters such as reading angles etc. and the values of such variables should be recorded with the test results.

6.7.2.3 Symbol Contrast

This test is designed to report the minimum values of symbol contrast at which the equipment under test can read. The test equipment described in 6.5.2 shall be used. The scanner shall be mounted so as to ensure that tilt and pitch angles shall be $0° \pm 2°$. The skew angle shall be such as to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 2, test chart no. 4 and test chart no. 6, with the Z dimension closest to 1,5 times the resolution of the equipment as determined in 6.7.2.1 shall be used. The test shall be performed twice, first with the subset of test symbols with decreasing values of R_{max} and next with the subset of test symbols with increasing values of R_{min}.

a) The test symbol with the highest symbol contrast value is fixed on the test equipment with the bar height perpendicular to the direction of movement so that the axis of the scanner exit window will pass through the midpoint of the bar height.

b) The distance "d" between scanner exit window and symbol shall be adjusted to the midpoint between the minimum and maximum reading distances for the Z dimension in use, as determined in 6.7.1.3.

c) The scanner is activated.

d) If the test criterion in 6.6 is met, then the test is repeated from step a) using test symbols with decreasing symbol contrast values to determine the lowest value of SC for which the test criterion in 6.6 can be met.

The test results should report the lowest symbol contrast value, the Z dimension, the skew angle, and record the distance "d" at which the test measurements were made. If different results are obtained with the two subsets of test symbols, both values of minimum symbol contrast shall be stated together with the corresponding values of R_{max} and R_{min}.

6.7.2.4 Ambient illumination

This test is used to determine the ambient light levels under which the scanner will operate.

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Use the procedure described in 6.7.1.5 except using the resolution as determined in section 6.7.2.1, the reading diagram as determined in section 6.7.2.2 and using additional test symbols from test chart no. 3 and test chart no. 5.

Perform the test for each ambient light level and record whether the test criterion in 6.6 is met.

6.7.2.5 Reading angles

This test is designed to report the minimum and maximum value of the three parameters, tilt, pitch and skew. The test shall be performed for each of the parameters individually while holding the other two constant at their initial values as defined under step a). The test equipment described in 6.5.2 shall be used and shall be set up as described in 6.7.2.1. The equipment under test is fixed mounted in a position such that the test symbol is on the central axis of the reading diagram at a distance “d” from the exit window midway between the minimum and maximum reading distances. A test bar code symbol from test chart no. 1, test chart no. 3 and test chart no. 5, with a Z dimension equal to or greater than the resolution of the equipment is used.

a) The test bar code symbol shall initially be fixed on the test equipment at a tilt angle of 0° (i.e. with the height of the bars perpendicular to the scan line of the scanner) and pitch and skew angles of 0° or (depending on which is being tested) the lowest angle required to avoid specular reflection.

b) The scanner is activated.

c) The relative angle of the test bar code symbol with respect to the scanner is progressively varied in steps of 5° (or smaller steps if appropriate) around the axis corresponding to the reading angle under test until the lowest and highest rotations at which the test criterion in 6.6 is met have been determined.

The test results should report, for each parameter, the minimum (if not 0°) and maximum angles, together with the Z dimension of the test symbol.

6.7.2.6 Lateral motion

This test is designed to determine if the scanner can read correctly when there is relative motion between the scanner and the test symbol. Use a test bar code symbol from test chart no. 1 with the Z dimension closest to 1,5 times the resolution of the equipment as determined in 6.7.2.1. Locate the test symbol on a large variable speed turn table or lateral motion stage with the ability to translate with a range of velocities appropriate to the applications for which the device is designed, for example 20 mm/sec to 100 mm/sec for certain handheld readers or 0,5 m/sec to 5 m/sec for fixed mount readers designed for installation alongside certain conveyor systems.

a) The distance “d” between the scanner exit window and symbol shall be adjusted to the midpoint between the minimum and maximum reading distances for the Z dimension in use, as determined in 6.7.2.2.

b) The scanner shall be mounted so as to ensure that tilt and pitch angles shall be $0 \pm 2°$. Nominally the skew angle shall be set normal at $0 \pm 2°$, however, if required, the skew angle shall be adjusted from the normal such as to avoid direct reflection from the bar code substrate and shall be reported with the result of the test.

c) Start the translation device at the lowest velocity in the range specified.

d) Attempt to read the test symbol as it moves in front of the scanner under test.

e) If the test criterion of 6.6 is satisfied, record the lateral motion test velocity.

f) Increase the translational velocity with by an increment of approximately 15% of the velocity and go to step c).

g) For 2 and 3 axis scanners, rotate the scanner and test symbol 90 degrees relative to the direction of motion and repeat the test from c).

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Report the Z dimension of the test symbol used, and the highest, and if appropriate the lowest, translational velocity for which the test criterion of 6.6 was satisfied in both orientations.

6.7.3 Scanners with three axis reading diagram – Multi-line scanners

The following tests are performed on the symbols from test sheets for both linear and multi-row symbologies. The test results should be recorded separately for each symbology used in the tests.

6.7.3.1 Resolution

This test is designed to report the minimum element width capable of being resolved by the equipment under test. The test equipment described in 6.5.3 shall be used. The scanner and symbol shall be mounted so as to ensure that tilt and pitch angles shall be 0°, ± 2°. The skew angle is chosen to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 1, test chart no. 3 and test chart no. 5, with a set of Z dimensions from 0,50 mm to 0,10 mm (or other values appropriate to the equipment under test) shall be used.

The test shall be performed as described in 6.7.1.1.

The test results should report the resolution in mm. and record the minimum distance “d” at which the test criterion is met with the test symbol with the Z value equal to the resolution of the scanner.

6.7.3.2 Reading diagram

This test is designed to determine the maximum and minimum reading distances, depth of field and the boundaries of the reading zone of the equipment under test. The test equipment described in 6.5.3 shall be used and shall be set up as described in 6.7.3.1. A reading diagram shall be determined using each of three or more test bar code symbols from test chart no. 1, test chart no. 3 and test chart no. 5, with different values of measured nominal dimension. The lowest Z dimension shall be equal to the resolution of the scanner from 6.7.3.1, the largest Z dimension shall be as specified by the manufacturer, and that of the third and subsequent symbols shall be approximately evenly spaced between the first two. The Z dimensions used shall be reported with the result of the test.

The test shall be carried out as described in 6.7.2.2, substituting the following step f):

f) The test symbol is moved laterally and vertically in each direction perpendicular to the central axis of the scanning pattern, to determine the farthest points at which the test criterion is still met. The boundary of the reading diagram at these points is defined as the outer edge of the quiet zone of the test symbol farther from the central axis of the scanning pattern. As the symbol is moved about, the symbol tilt, pitch and skew may be varied during the test to maintain the angles as specified in step a), measured relative to the scan line in the portion of the scan pattern near the symbol.

The test results should report, for each Z dimension used for the test, the minimum and maximum reading distances and the depth of field as the difference between these reading distances in mm; the reading diagram should represent the limits of the reading zone.

Note that additional reading diagrams should be determined for different values of symbol contrast using test symbols from test chart no. 2, test chart no. 4 and test chart no. 6, and may be determined for variations in other parameters such as reading angles etc. and the values of such variables should be recorded with the test results.

6.7.3.3 Symbol contrast

This test is designed to report the minimum values of symbol contrast at which the equipment under test can read. The test equipment described in 6.5.3 shall be used. The scanner shall be mounted so as to ensure that tilt and pitch angles shall be 0° ± 2°. The skew angle shall be such as to avoid direct reflection from the bar code substrate and shall be reported with the result of the test. A series of test bar code symbols from test chart no. 2, test chart no. 4 and test chart no. 6, with the Z dimension closest to 1,5 times the resolution of the

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equipment as determined in 6.7.3.1 shall be used. The test shall be performed twice, first with the subset of test symbols with decreasing values of R_{max} and next with the subset of test symbols with increasing values of R_{min}.

The test shall be performed as described in 6.7.2.3, with the test symbol mounted on the central axis of the reading diagram at the midpoint between the minimum and maximum reading distances for the Z dimension in use.

The test results should report the lowest symbol contrast value, the Z dimension, the skew angle, and record the distance "d" at which the test measurements were made. If different results are obtained with the two subsets of test symbols, both values of minimum symbol contrast shall be stated together with the corresponding values of R_{max} and R_{min}.

6.7.3.4 Ambient illumination

This test is used to determine the ambient light levels under which the scanner will operate.

Use the procedure described in 6.7.1.5 except using the resolution as determined in section 6.7.3.1, the reading diagram as determined in section 6.7.3.2 and using additional test symbols from test chart no. 3 and test chart no. 5.

6.7.3.5 Reading angles

This test is designed to report the minimum and maximum value of the three parameters, tilt, pitch and skew. The test shall be performed for each of the parameters individually while holding the other two constant at their initial values as defined under step a) of 6.7.2.5. The test equipment described in 6.5.3 shall be used and shall be set up as described in 6.7.3.1. The equipment under test is fixed mounted in a position such that the test symbol is on the central axis of the reading diagram at a distance "d" from the exit window midway between the minimum and maximum reading distances. A test bar code symbol from test chart no. 1, test chart no. 3 and test chart no. 5, with a Z dimension equal to or greater than the resolution of the equipment is used.

The test shall be performed as described in 6.7.2.5.

The test results should report the minimum (if not 0°) and maximum values of tilt, pitch and skew angles together with the Z dimension used for the test.

6.7.3.6 Lateral motion

The test should be performed as described in 6.7.2.6.

6.7.4 Scanners with three axis reading diagram – Image scanners

Image scanners shall be tested according to 6.7.3 with the restriction that only complete reading systems shall be tested. Additional test symbols from test chart no. 7 and test chart no. 8 shall be used for the appropriate tests.

When testing tilt, the test symbols shall be rotated in 45 degree steps though 180 degrees of total rotation.

For the lateral motion test, the test symbol shall be tested and reported for two orientations: with the bars parallel to the lateral motion and with the bars perpendicular to the lateral motion.

6.7.5 Decoder

The requirements set out below are applicable to decoders being tested independently of a scanner.

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6.7.5.1 Symbologies

A decoder is generally able to decode different bar code symbologies.

The manufacturer shall specify:

- the symbologies supported and for each of them the maximum number of characters and other optional features capable of being processed;
- how many symbologies, and which ones can be decoded in autodiscrimination;
- whether symbology identifiers in accordance with ISO/IEC 15424 can be transmitted; if a non-standard method of identifying the symbology is used, this should be defined.

6.7.5.2 Decoder Resolution

In order to extract the information from the signals coming from the scanner, the decoder must first of all measure the duration of a series of impulses. This test is designed to determine the minimum impulse the decoder is able to measure correctly. The test equipment described in 6.5.4.2 shall be used and shall be connected to the input of the decoder. The auxiliary equipment referred to in 6.5.4.2 shall be connected to the output of the decoder.

a) The signal generator shall be adjusted so that the duration of the minimum pulse width in the pulse string sent to the decoder is below the expected decoder resolution.

b) The pulse string shall be sent to the decoder.

c) If the test criterion defined in 6.6.1 is not met, the pulse widths in the pulse string shall be increased proportionally and progressively until the test criterion is met. The duration of the minimum pulse width is equivalent to the decoder resolution.

d) The test shall be repeated using progressively wider pulse widths until the maximum width is attained at which the test criterion is still met.

The test results shall report the minimum and maximum pulse widths for which the decoder is capable of correctly decoding the input pulse string. These minimum and maximum values should be expressed in appropriate time units.

6.7.5.3 Decoding Performance

The test equipment described in 6.5.4.2 shall be used and shall be connected to the input of the decoder. The auxiliary equipment referred to in 6.5.4.2 shall be connected to the output of the decoder.

a) The signal generator shall be programmed to output a pulse string corresponding to the element pattern of a correctly encoded symbol in a symbology intended to be decoded by the decoder, and the decoder shall if necessary be set to accept symbols in this symbology. The minimum pulse width in the pulse string sent to the decoder shall be the manufacturer's minimum recommended resolution and shall be within the resolution range of the decoder as determined in 6.7.5.2.

b) The pulse string shall be sent to the decoder.

c) The decoded data output by the decoder shall be compared with the data encoded in the input pulse string.

d) If the two sets of data do not correspond the test result shall be recorded as a failure for the combination of symbology and options encoded in the pulse string.

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e) The test shall be repeated using pulse strings corresponding to different sets of data and implementing optional features of the symbology encoded (e.g. test data with or without optional check characters) and for each symbology from the set supported by the decoder. For each of these tests the decoder shall be set appropriately and the detailed configuration recorded with the test results.

f) For autodiscriminating decoders the test shall comprise test data encoded in different symbologies, including the set of symbologies for which decoding is currently enabled in the decoder and symbologies outside the set (the latter shall not be decoded).

g) The test shall be repeated with relevant optional decoder features enabled and disabled, e.g. validation of check characters, transmission of check characters or start and stop characters, and transmission of symbology identifiers, and with different levels of decode redundancy, if user-configurable. The data output shall be compared with the expected output and if the two sets of data do not correspond the test result shall be recorded as a failure for the particular combination of optional features and symbology. The detailed decoder configuration shall be recorded with the test results.

6.7.6 Complete Reading Systems

6.7.6.1 Scanning Performance

The scanning performance of the system shall be tested in accordance with 6.7.1, 6.7.2, 6.7.3 or 6.7.4 as appropriate to the type of scanner incorporated and substituting the test criterion in 6.6.1 for that in 6.6.2.

The test results shall record the data appropriate to the type of scanner, as defined in 6.7.1, 6.7.2, 6.7.3 or 6.7.4.

6.7.6.2 Decoding performance

The decoding performance of the system shall be tested in accordance with 6.7.5, omitting 6.7.5.2 and substituting for the signal generator in 6.5.4.2 a series of test symbols, the dimensional and reflectance characteristics of which match the scanning performance of the reading system under test. The test symbols shall comply with the relevant symbology specification. For each symbology supported, the test symbols should include the complete character set of the symbology and should also enable the decoder's processing of optional features of the symbology to be tested. For example they should include symbols with both correct and incorrect symbol check characters. The data expected to be output by a correctly functioning decoder shall be supplied with the test symbols.

The test results shall report the test symbols used and the results of the reading attempts.

6.8 Test report

The test report shall comprise a record of the test conditions, equipment configuration including auxiliary equipment as described in 6.5 and test charts or symbols used, together with the test results in accordance with 6.7. A copy of the test report shall be made available to bona fide enquirers on request.

A manufacturer may wish to publish a partial list of test results from those described in this specification.

7 Certification and labelling

The manufacturer shall include with the equipment documentation a declaration that the equipment has been tested in conformity with this International Standard.

The manufacturer may affix labels to the equipment indicating that it has been tested in conformity with this International Standard. No requirements are defined for this labelling.

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8 Equipment specification

8.1 General

Although each scanner tested is nominally representative, scanners of the same model may produce different results. A manufacturer may therefore derate the test results for his published scanner specifications to allow for manufacturing tolerances and insure that all the scanners of the same type comply with his specifications. Manufacturer's published performance specifications shall be capable of being substantiated by the use of the test methods defined in this International standard. Manufacturers of equipment should specify:

- a) for scanners:
  - scanner type;
  - light source and nominal peak wavelength, if applicable;
  - statements of compliance with any applicable regulation (e.g. laser classification);
  - performance parameters determined by testing in accordance with this International Standard;
  - scanning rate in scans per second or scan lines per second, if appropriate;
  - ambient light conditions under which the equipment is intended to be used;
  - interface details for decoder connection in accordance with 8.2;
  - if desired, minimum and maximum speeds at which test symbols from test chart no. 1 may be transported through the scanner's reading zone while meeting the criterion in 6.6, together with details of the test conditions.
- b) for decoders:
  - symbologies supported and which ones may be decoded in autodiscrimination;
  - optional features of symbologies supported (e.g. symbology identifiers);
  - decode redundancy if user-configurable;
  - interface details for scanner connection in accordance with 8.2;
  - human interface details in accordance with 8.3;
  - computer interface details in accordance with 8.4;
  - digital inputs and outputs in accordance with 8.5;
  - programming and configuration method in accordance with 8.6.
- c) for complete reading systems:
  - Information in accordance with a) and b) above, excluding interface details for scanner/decoder interconnection.

For all types of equipment, the manufacturer shall specify the general operational requirements as described in Annex A.

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8.2 Scanner/decoder interface

Except for complete reading systems, the manufacturer shall specify the physical, logical and electrical characteristics of the scanner output or decoder input to enable the decoder input or scanner output respectively to be connected reliably to it, and in particular:

- a) physical:
  - type of connector;
  - assignment of pins.
- b) logical:
  - available signals and their functions;
    - logic level meaning (e.g. logic level 0 = light status, logic level 1 = dark status);
    - timing diagram for the available signals.
- c) electrical:
  - maximum sink and source current;
  - voltage values for each logic level, measured with the maximum values of sink and source current;
  - applicable logic input threshold levels (i.e. minimum voltage for high logic level and maximum voltage for low logic level);
  - maximum rise and fall times of the digital signal;
  - (for open collector and open drain interfaces) the maximum permitted external voltage;
  - (for opto-insulated interfaces) the maximum value of insulation voltage.

8.3 Human interface

The manufacturer shall specify:

- type of indicators and their function;
- type of display with their parameters;
- keyboard function, if there is one available;
- audible output parameters.

8.4 Computer interface

The manufacturer shall specify:

- type and number of interfaces;
- use of the interfaces at the same time;
- timing diagram;

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— types of protocol;

— applicable communications parameters (e.g. baud rate).

8.5 Digital input and output (I/O)

The manufacturer shall specify:

— type and number of I/O's.

8.6 Programming and configuration

The manufacturer shall specify how the decoder is to be programmed or configured, for example to enable or disable decoding of a particular symbology, to validate and transmit check characters, to accept defined message lengths, to set decode redundancy levels etc.

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Annex A
(normative)

General operational requirements

A.1 Installation, operation and maintenance – general

The manufacturer shall specify in documentation provided for or available to the installer, user and maintainer of the equipment the conditions for installation, operation and maintenance of the equipment. These documents shall indicate the recommended extent and frequency of maintenance, if any. When equipment which is the subject of this International Standard is installed, operated or maintained in accordance with the above conditions, it shall be capable of operating as specified in the following subsections.

A.2 Power supply

The manufacturer shall indicate the minimum and maximum parameters of the power supply at which the device is able to operate according to its specifications.

A.3 Temperature

A.3.1 Operating temperature range

The manufacturer shall state the range of temperatures in degrees Celsius within which the equipment will operate.

A.3.2 Storage temperature range

The manufacturer shall state the range of temperatures in degrees Celsius which the equipment (including removable batteries) shall be capable of withstanding during storage and transportation, without loss of performance.

A.4 Humidity

The manufacturer shall state the range of values of relative humidity (RH) of the air within which the equipment will operate and whether the environment is condensing or non-condensing.

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Annex B
(informative)

Classification of scanners

The reading diagram is of great assistance in providing a complete overview of the performance of a bar code scanner/reader, and forms the basis on which scanners have been classified for the purposes of this International Standard.

B.1 Types of scanner

B.1.1 Scanners with single axis reading diagram

This category comprises all scanners with a single, fixed reading beam which therefore require movement of the symbol and scanner relative to each other to achieve a scan of the symbol.

Examples of scanners with a single axis reading diagram include:

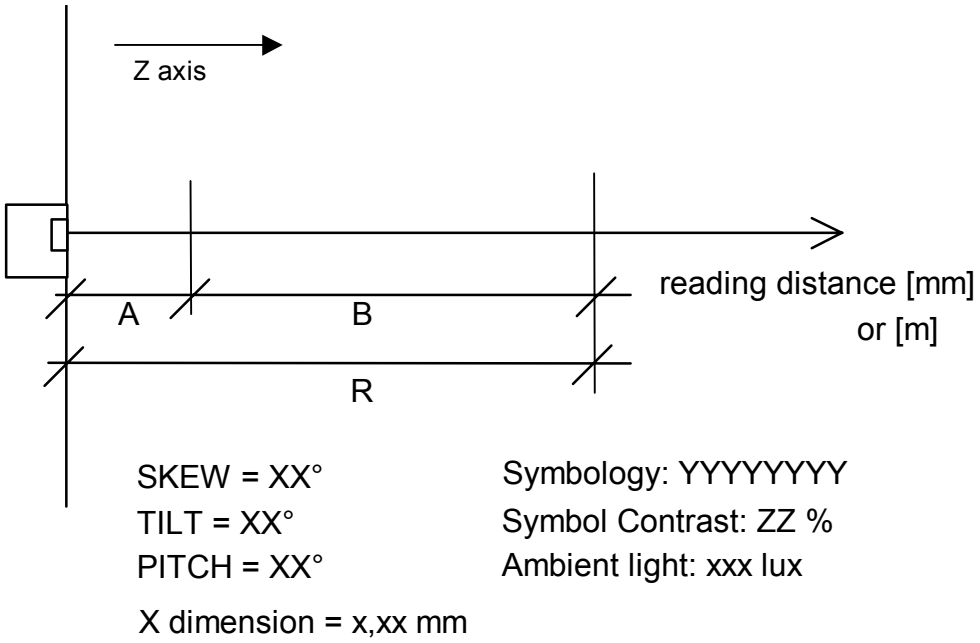
— Fixed beam scanners. These are generally non-contact scanners with a laser or other light source.

— Light pens or wands. These are hand-held pencil-shaped devices the tip of which is the exit window and is passed across the symbol manually, in contact with it. They have negligible depth of field.

— Slot readers. Otherwise known as badge readers. They comprise a slot through which the bar code symbol is slid manually past, and in near contact with, an optical arrangement closely similar to that of a light pen. The word “reader” is a misnomer in that these devices do not necessarily include a decoder, but the name is retained because of the confusion which would arise with “slot scanner”, a term given to a type of omni-directional laser scanner used for electronic point of sale scanning.

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Scanner with single axis reading diagram	
Parameter	Term
A	minimum reading distance
B	depth of field
R	maximum reading distance

Figure B.1 — Reading diagram for single-axis scanner

B.1.2 Scanners with two axis reading diagram

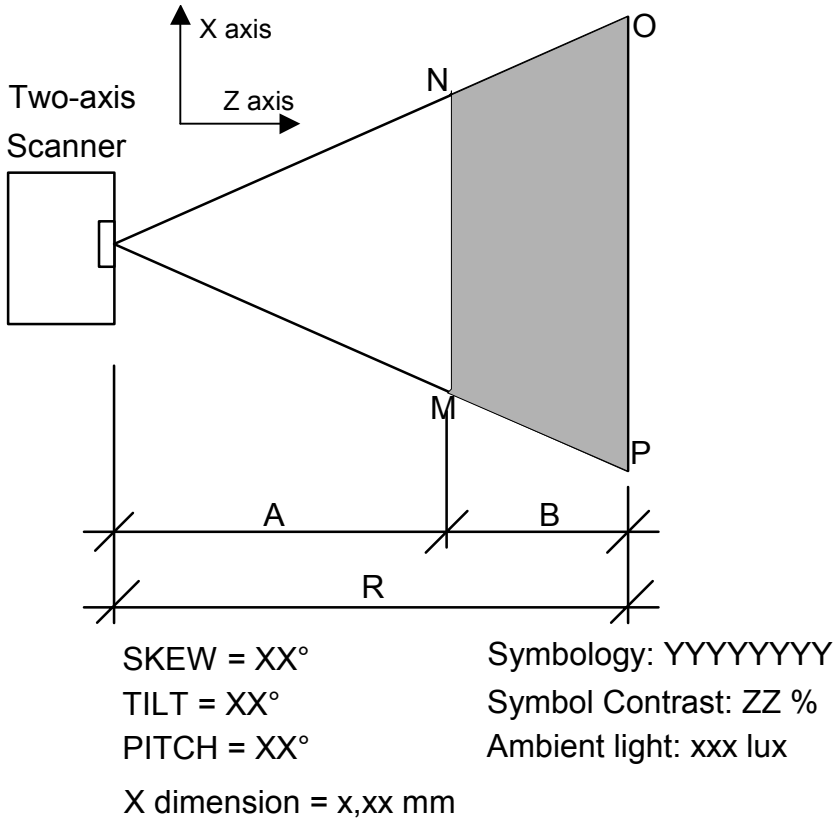
This category comprises all scanners with a reading beam which is effectively swept (either optically or electronically) in a single plane and are therefore capable of scanning symbols through which this plane passes.

Examples of scanners with a two axis reading diagram include:

— Moving beam scanners. In these, scanning action is achieved by mechanically or electronically moving a light beam, generally a laser beam, across a bar code symbol. Because the light beam is moving, these readers can read stationary or moving bar codes.

— Linear imaging scanners. The scanning is accomplished with an array of LED's or another light source flooding the bar code with light and focussing the image on a CCD or CMOS array which is electronically sampled. In a linear imaging scanner with a two axis reading diagram, a linear CCD or CMOS array is used.

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Scanner with two axis reading diagram	
Parameter	Term
A	minimum reading distance
B	depth of field
R	maximum reading distance
MNOP	reading zone

Figure B.2 — Reading diagram for two-axis scanner

B.1.3 Scanners with three axis reading diagram

This category comprises all scanners with a reading beam which is effectively swept (either optically or electronically) in multiple planes and which are therefore capable of multiple scan paths through a symbol or of scanning a symbol the position of which may vary in three axes. In some cases the orientation of the symbol relative to the scanner may vary.

Examples of scanners with a three axis reading diagram include:

— Raster scanners. These are moving beam scanners where an additional oscillating mirror or a rotating faceted mirror with individual facets mounted at slightly different angles causes the scanning beam to cover a three-dimensional volume rather than a single plane area.

— Omnidirectional scanners. In these, a pattern of scanning beams is created covering the volume to be scanned at many angles (either as a series of planar beams at different angles or as a complex Lissajous figure), enabling a symbol rotated at any tilt angle to be scanned.

— Multi-window scanners. These are omnidirectional scanners with two or more exit windows in more than one plane. They are designed to enable the scanning of multiple sides of an item simultaneously. Testing of performance of these by taking individual exit windows independently may require the test equipment

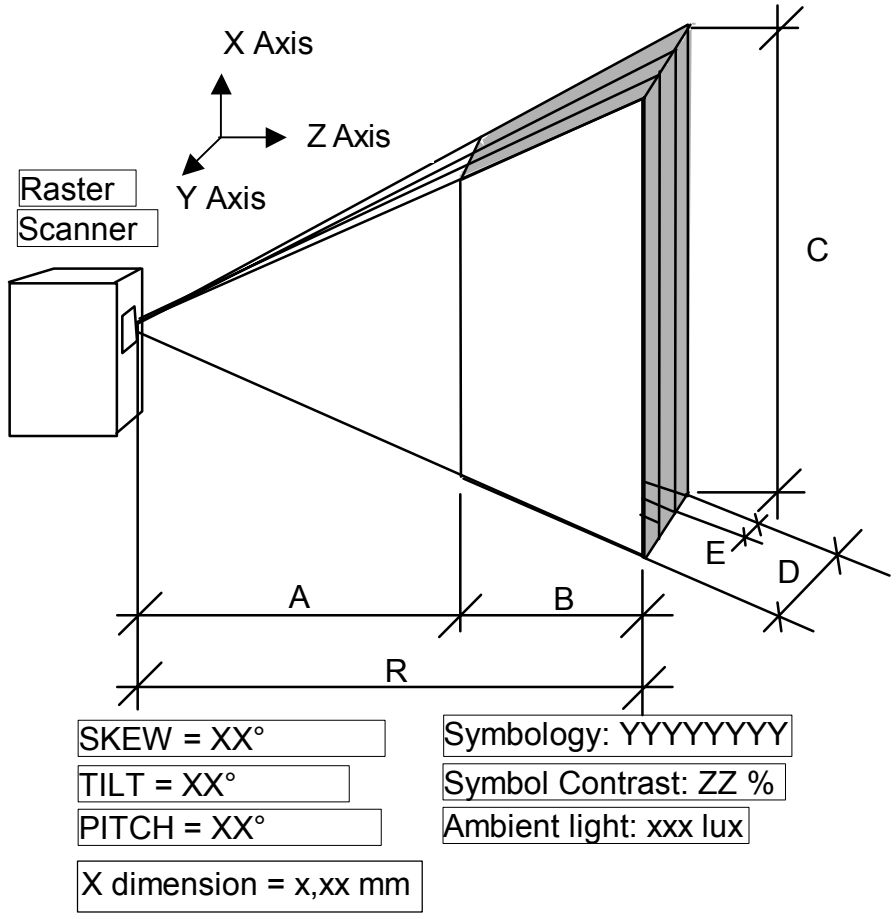
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and set-up specified in this standard to be modified, and may not fully reflect the performance of the equipment. It may, therefore, only be meaningful to test a selection of the parameters defined in this standard.

— Holographic scanners. These are omnidirectional scanners using holographic optical elements to project and/or collect the scanning beam in multiple focal planes, enabling increased depth of field to be obtained.

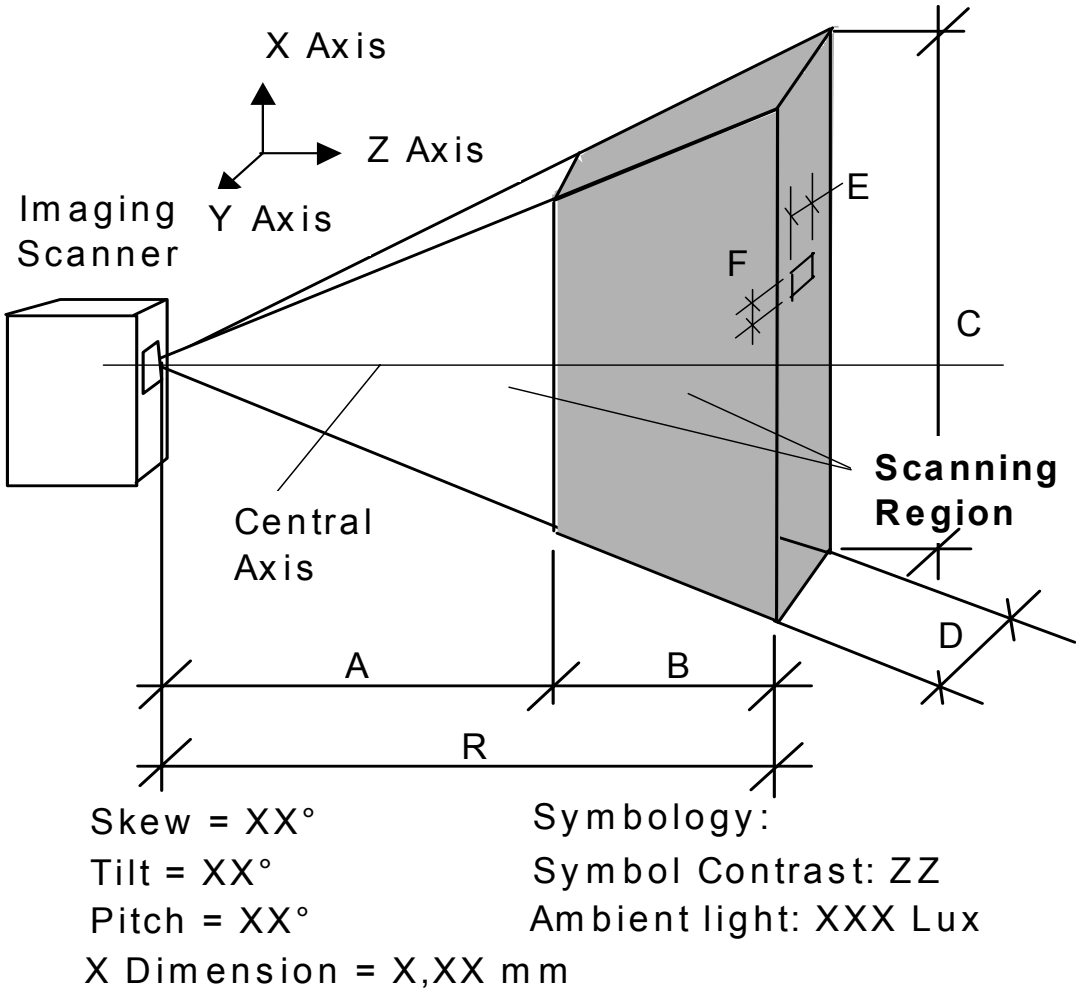
— Area array or two-dimensional imaging scanners. These are analogous to the linear imaging device with the image being captured on a two-dimensional pixel array, and use image processing techniques to extract the electronic image of the bar code symbol. Typically either CCD or CMOS area imagers are used.



Scanner with three axis reading diagram	
Parameter	Term
A	minimum reading distance
B	depth of field
R	maximum reading distance
E	raster separation
D	raster width
C	scan height
B x C x D	reading zone

Figure B.3 — Reading diagram for a raster three-axis scanner

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Parameter	Term
A	minimum reading distance
B	depth of field
R	maximum reading distance
E	Y axis pixel pitch
F	X axis pixel pitch
C	scan height
D	scan width
B x C x D	reading zone

Figure B.4 — Reading diagram for an imaging three-axis scanner

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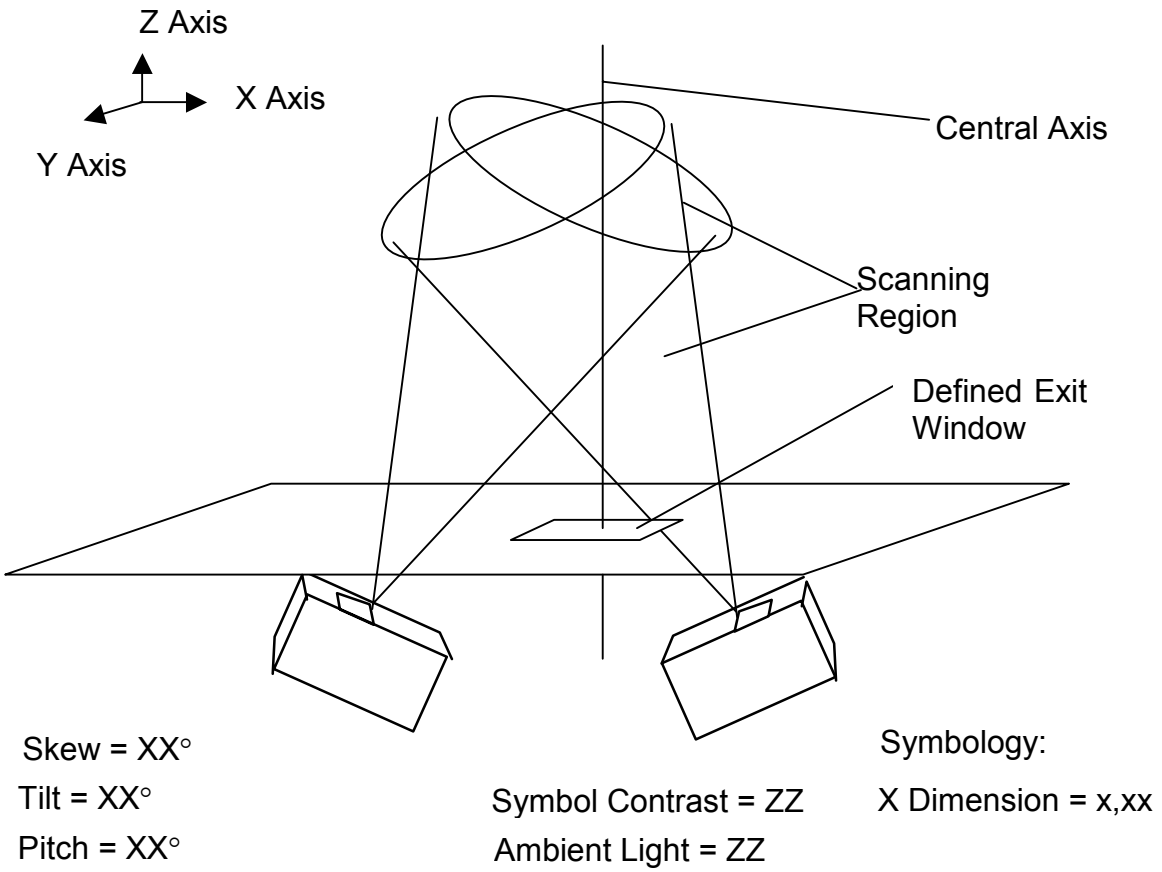


Figure B.5 — Multi-window scanner diagram

B.2 Additional methods of categorization

For many applications it is useful to classify scanners by other features. Most common are subdivision into contact/non-contact devices, or into hand-held/fixed mount devices. They may also be independent units or integrated with decoders, and again integrated into other forms of unit such as a portable hand-held data capture (and processing) terminal. These distinctions are of little or no relevance to this International Standard, although clearly they are essential to a prospective user.

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Annex C
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Example of decodability calculation

This Annex illustrates the calculation of the "decodability" value for the character 2 encoded in Code 128, based on hypothetical scan times derived from a scanner output, in order to verify that the character meets the test criterion set out in 6.6.2. The decodability parameter is defined in ISO/IEC 15416 and the general form of the calculation given there; symbology standards may contain additional calculations to enable this parameter to be applied to their specific reference decode algorithms. Code 128, its reference decode algorithm, and its associated special calculation of decodability are defined in ISO/IEC 15417.

The symbols used below are consistent with those in the two standards referred to.

Example:

The total scan duration S for the character is 5,50 ms. Since there are 11 modules in a Code 128 character, the nominal Z module scan duration is (5,50 / 11) = 0,50 ms.

From this the reference thresholds can be calculated, using the formula $Rt_j = (1 + 2j)\ S / 22$:

j	1	2	3	4	5	6	7
Rt_j (ms)	0,75	1,25	1,75	2,25	2,75	3,25	3,75

Given the measured scan durations for each of the elements in the character, the edge to similar edge values e_i can be calculated and, by applying the reference threshold values above, the normalised E_i measurements in modules are obtained.

Element	1 (bar)	2 (space)	3 (bar)	4 (space)	5 (bar)	6 (space)
Scan duration (ms)	1,20	0,80	1,55	1,00	0,50	0,45
e_1	2,00					
e_2		2,35				
e_3			2,55			
e_4				1,50		

The corresponding E_i values are:

E_1 = 4 modules
E_2 = 5 modules
E_3 = 5 modules
E_4 = 3 modules

This set of values corresponds to the symbol character 2 in Code 128, consisting of the bar-space pattern (in modules) 2-2-3-2-1-1.

The decodability value V in Code 128 is defined as the lesser of V_1 and V_2,

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where $V_1 = K / (S/22)$
(in which K is the absolute value of the smallest deviation of e_i from Rt_j, for i = 1 to 4 and j = 1 to 7)

$V_2 = (1,75 - |11 * Wb / S - M|) / 1,75$
(in which Wb is the sum of the measured bar widths
S is the measured scan duration for the character
M is the sum of the bar widths in modules).

K in this instance is the difference between e_2 and RT_4, i.e. ABS(2,35 - 2,25) = 0,10.

Wb = (1,20 + 1,55 + 0,50) = 3,25

M = (2 + 3 + 1) = 6

Substituting measured values:

V_1 = 0,10 / (5,50 / 22) = 0,10 / 0,25 = 0,40

V_2 = {1,75 - [(11 * 3,25 / 5,50) - 6]} / 1,75

= {1,75 -[(35,75 / 5,50) - 6]} / 1,75

= [1,75 -(6,5 - 6)] / 1,75

= 1,25 / 1,75

= 0,71

Since V_1, at 0,40, is less than V_2, at 0,71, the value of V is taken as 0,40, which is within the range for grade 2, and the character therefore meets the criterion in 6.6.2.

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