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Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specification —

Part 2: Two-dimensional symbols

Technologies de l'information — Techniques d'identification automatique et de capture de données — Spécifications de conformité des vérificateurs de codes à barres —

Partie 2: Symboles bidimensionnels

Reference number
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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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 15426-2 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

ISO/IEC 15426 consists of the following parts, under the general title *Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specification*:

— *Part 1: Linear symbols*

— *Part 2: Two-dimensional symbols*

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Introduction

The technology of bar coding is based on the recognition of patterns encoded, in bars and spaces or in a matrix of modules of defined dimensions, according to rules defining the translation of characters into such patterns, known as the symbology specification. Symbology specifications may be categorised into linear symbols, on the one hand, and two-dimensional symbols on the other; the latter may in turn be sub-divided into «multi-row bar codes» sometimes referred to as «stacked bar codes», and «two-dimensional matrix codes».

Multi-row bar codes are constructed graphically as a series of rows of symbol characters, representing data and overhead components, placed in a defined vertical arrangement to form a (normally) rectangular symbol, which contains a single data message. Each row of the symbol has the characteristics of a linear bar code symbol and may be read by linear symbol scanning techniques.

Two-dimensional matrix symbols are usually rectangular arrangements of modules placed at the intersections of a grid of two (sometimes more) axes; the coordinates of each module need to be known in order to determine its significance, and the symbol must therefore be analysed two-dimensionally before it can be decoded.

Unless the context requires otherwise, the term «symbol» in this part of ISO/IEC 15426 may refer to either type of symbology.

The symbol, as a machine-readable data carrier, 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. Standard methodologies have been developed for measuring and assessing the quality of symbols for process control and quality assurance purposes during symbol production as well as afterwards.

Manufacturers of bar code equipment, the producers of bar code symbols and the users of bar code technology require publicly available standard conformance specifications for measuring equipment applying these methodologies, to ensure the accuracy and consistency of performance of this equipment.

This part of ISO/IEC 15426 is intended to be similar in technical content (mutatis mutandis) to the linear bar code verifier conformance standard, ISO/IEC 15426-1, on which it has been based. It should be read in conjunction with the symbology specification applicable to the bar code symbol being tested, which provides symbology-specific detail necessary for its application.

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Information technology — Automatic identification and data capture techniques — Bar code verifier conformance specification —

Part 2: Two-dimensional symbols

1 Scope

This part of ISO/IEC 15426 defines test methods and minimum accuracy criteria applicable to verifiers using the methodologies of ISO/IEC 15415 for multi-row bar code symbols and two-dimensional matrix symbologies, and specifies reference calibration standards against which these should be tested. This part of ISO/IEC 15426 provides for testing of representative samples of the equipment.

NOTE ISO/IEC 15426-1 applies to verifiers for linear bar code symbols.

2 Conformance

The instrument shall be considered to conform with this part of ISO/IEC 15426 if it performs the functions defined in 6.3 and if the results of measurements of primary reference test symbols carried out in accordance with Clause 8 demonstrate that the arithmetic means of the ten measurements (for multi-row bar code symbols) or five measurements (for two-dimensional matrix symbols) of individual reported parameters are within the tolerances shown in Table 1 below.

Table 1 — Tolerances for measured parameter values

Parameter	Symbology type	Tolerance
R_{max} and/or R_s	Both	± 5 % reflectance
R_{min} and/or R_b	Both	± 3 % reflectance
UEC	Both	± 0,0
Decodability	Multi-row	± 0,08
Defects	Multi-row	± 0,08
Codeword Yield	Multi-row	± 0,08
Grid Nonuniformity	Matrix	± 0,06
Modulation	Matrix	± 0,08 of the value measured for the reduced dark widow on a calibrated test symbol card
Fixed Pattern Damage	Matrix	Within calibrated grade boundaries

NOTE The tolerances in Table 1 are additional to any tolerances stated by the supplier of the primary reference test symbols.

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3 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 2859-1:1999, *Sampling procedures for inspection by attributes — Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 9001:2000, *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 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 19762 (all parts), *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary*

ISO/IEC 18004, *Information technology —Automatic identification and data capture techniques — Bar code symbology — QR Code*

4 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 15415, ISO/IEC 19762 (all parts) and the following apply.

4.1
primary reference test symbol
bar code symbol intended for the testing of the accuracy of bar code verifiers and manufactured to close tolerances, of at least ten times the precision listed in Table 1, by methods traceable to national standards

5 Symbols

R_b Bar Reflectance, as defined in ISO/IEC 15416

R_{max} Maximum reflectance, as defined in ISO/IEC 15416

R_{min} Minimum reflectance, as defined in ISO/IEC 15416

R_s Space Reflectance, as defined in ISO/IEC 15416

6 Functional requirements

6.1 General requirements

The general requirement of a two-dimensional symbol verifier is that it shall provide assessments of the quality of a bar code symbol which are accurate and consistent, both in relation to measurements of a specific

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symbol made with the same instrument over a period of time and in relation to measurements of a specific symbol made by different instruments. Such consistency is essential to enable valid comparisons to be made of assessments of a symbol verified at two different times or on two different instruments.

6.2 Reflectance calibration

Verifiers shall have means of calibration and adjustment where necessary of reflectance values against reference reflectance calibration samples. Two calibration points should be used, one as near the high reflectance end of the range and the other as near the low reflectance end of the range as possible.

ISO/IEC 15415 defines the reference reflectance material against which these samples shall be calibrated.

6.3 Mandatory functions

6.3.1 Verifiers for multi-row bar code symbols

A verifier for multi-row bar code symbols applying the methodology defined in ISO/IEC 15415 shall be capable of:

— collecting reflectance measurements from points along multiple scan paths across a bar code symbol;

— establishing scan reflectance profiles from these measurements;

— analysing the scan reflectance profiles;

— reporting individual scan reflectance profile parameter grades and profile grades;

— reporting the Codeword Yield value and grade;

— reporting the Unused Error Correction value and grade;

— determining and reporting an overall symbol grade;

— reporting the decoded data.

6.3.2 Verifiers for two-dimensional matrix symbols

A verifier for two-dimensional matrix symbols applying the methodology defined in ISO/IEC 15415 shall be capable of:

— collecting reflectance measurements from a sample area framing the test symbol and its quiet zones, extending for certain symbol sizes 20X beyond the quiet zones (see Clause 10);

— establishing a reference grey-scale image and a binarised image as described in ISO/IEC 15415;

— decoding these images in accordance with the applicable reference decode algorithm;

— reporting individual values and grades for each of the parameters listed in ISO/IEC 15415;

— determining and reporting an overall symbol grade;

— appending an asterisk to the reported overall symbol grade, for certain symbol sizes, under the additional reflectance check provisions of ISO/IEC 15415;

— reporting the decoded data.

The method of reporting is not specified but may be by means of, for example, a display screen in the instrument, a printed report, or electronic communication with another device such as a computer.

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6.4 Optional functions

Users of verifiers have differing requirements for the amount of detail reported by the instrument, and a verifier may therefore perform additional functions, for example:

— reporting of number of scan reflectance profiles or images on which the overall symbol grade is based;

— reporting of print growth in one or both axes;

— reporting of symbology verified;

— reporting all decoded symbol characters or codewords;

— print-out or display of all or, at the user's option, selected scan reflectance profiles or images.

7 General constructional and operational requirements

7.1 Installation, operation and maintenance

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 part of ISO/IEC 15426 is installed, operated and maintained in accordance with the above conditions, it shall be capable of operating as specified.

7.2 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. The accuracy of the bar code verifier shall not be adversely affected by fluctuations in supply voltage and frequency within the range specified by the manufacturer.

In the case of battery-powered equipment, the instrument shall either give a warning signal to the operator or shall cease to operate when approaching the battery power limit at which the reliable performance of the instrument can no longer be guaranteed. For equipment powered by rechargeable batteries, the manufacturer shall indicate the requirements for recharging the batteries.

7.3 Temperature

7.3.1 Operating temperature range

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

7.3.2 Storage temperature range

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

7.4 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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7.5 Ambient light immunity

The characteristics of ambient light vary very widely and should be taken into consideration. Some examples of typical light sources which may be the cause of problems are high-efficiency fluorescent lighting, sodium vapour lamps, mercury vapour lamps, red neon lights and direct sunlight.

The manufacturer shall state the recommended ambient light conditions under which the equipment is intended to be used.

8 Test requirements

8.1 Test methods

Manufacturers' test procedures should be in accordance with the requirements of ISO 9001. The methodology defined in ISO/IEC 15415 shall be followed.

8.1.1 Selection of equipment for testing

Tests shall be carried out on at least one verifier which has been selected from a production batch in accordance with the manufacturer's own quality control sampling scheme. The manufacturer should implement a quality programme to assure that all similar devices will satisfy the requirements of this part of ISO/IEC 15426.

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

8.1.2 Scanning parameters

Scanning and other equipment use parameters during the tests shall fall within the range specified by the manufacturer of the equipment.

8.1.3 Test measurements

The overall symbol grade, and the values for the individually measured parameters reported by the instrument, shall be compared with the actual measurements supplied with the test symbols.

Should performance for symbologies other than those listed in Annex A require to be tested, test symbols should be used which conform with the relevant symbology specification and which have been measured on a calibrated verifier conforming with this part of ISO/IEC 15426. The parameters which require testing for these symbologies are Decode (for all symbols), Decodability (for multi-row bar code symbols), Unused Error Correction and Fixed Pattern Damage (for two-dimensional matrix symbols), to ensure that the verifier applies the reference decode algorithm defined in the symbology specification. Other parameters are fully covered by the reference test symbols defined in Annex A, provided that the verifier is designed to measure these.

8.2 Test environment

Tests on bar code verifiers shall be conducted under manufacturer-specified environmental conditions. These should, as a minimum, include the power supply, temperature, relative humidity and ambient light conditions.

8.3 Primary reference test symbols

All tests for conformance with this part of ISO/IEC 15426 shall be carried out using a selection of primary reference test symbols. Primary reference test symbols are used because their scan reflectance profiles or images present known values of specific parameters to the manufacturer or user of a verifier. The values are determined by a measurement device that mimics the commercial verification device methodology and has national standard traceable performance on the reflectance and on the linear distance axes at a magnitude of

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ten times better than the commercial verification device. Annex A lists an appropriate range of primary reference test symbols. Annex B describes the verification requirements for primary reference test symbols.

If multiple light sources with different spectral characteristics or measuring apertures/effective resolutions are commonly used within the scanning environment for the symbol in question, a primary reference test symbol with multiple spectral and aperture/effective resolution calibration points may be required. In all cases, the primary reference test symbols shall conform with the relevant symbology specification (national, regional or International Standard if one exists, or a recognised industry specification, for the symbology in question) and shall be supplied with a statement of:

— the symbology used;

— the data encoded;

— measurement aperture(s) or effective resolution and spectral characteristics (e.g. peak wavelength(s) or colour temperature(s)) of light used for calibration;

— overall symbol grade in accordance with ISO/IEC 15416 or ISO/IEC 15415;

— an individual parameter grade and value in accordance with ISO/IEC 15416 or ISO/IEC 15415 (if the primary reference test symbol variation is designed to emphasise a particular parameter within the scan reflectance profile or image).

Primary reference test symbols shall be used for the purposes of type testing of verification equipment by conformance testing laboratories, and by manufacturers of verification equipment for the purpose of self-certification of conformity with this part of ISO/IEC 15426. A subset of the primary reference test symbols may be compiled for verifier users. This subset of primary reference test symbols would provide the users with the means for periodic calibration checks of their verifier and for training in the proper use of their instrument.

Primary reference test symbols shall be produced on materials which show negligible dimensional variation with changes in temperature and humidity under ambient conditions of 10°C to 30°C and 30% to 70% R.H. Consideration should be given to the use of materials that will retain or return to their original dimensions after being transported under conditions that may be outside these ranges.

Verification device manufacturers and users may choose to use, as part of their routine quality assurance procedures, secondary test symbols. The parameter values for secondary test symbols shall have been determined through the use of a verifier the calibration of which has been checked against primary reference test symbols. While secondary test symbols may be used for routine quality assurance procedures, they do not provide the basis for a statement of conformance with this part of ISO/IEC 15426.

8.4 Test report

The test environment, equipment configuration, scanning parameters, and primary reference test symbols used shall be recorded together with the following:

— symbology(ies) tested;

— overall symbol grade as measured and reported by the instrument and as defined for the primary reference test symbol in question;

— the values for the individually measured parameters;

— confirmation that values measured are within the tolerances defined in Clause 2.

Copies of the reports output by the verifier under test, if available, shall be attached to the test report. These may, for example, be printed reports or prints of the screen display of a computer to which the verifier is connected. A copy of the test report shall be made available to bona fide enquirers on request.

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9 Certification and labelling

The manufacturer shall include with the verifier documentation a declaration that the equipment has been tested in accordance with this part of ISO/IEC 15426.

The manufacturer may affix labels to the equipment indicating that the verifier conforms to this part of ISO/IEC 15426. No requirements are defined for this labelling.

10 Equipment specification

The manufacturer should specify the following in documentation available to users of the equipment:

- which symbologies the verifier is capable of verifying, including the identification of optional features of the symbologies which are supported;
- the measuring apertures or effective resolutions available;
- the overall sizes of symbols (relative to ranges of X dimension) that can be verified
  - including the additional reflectance check of an area extending 20 X beyond the quiet zone of a matrix symbol specified in ISO/IEC 15415,
  - excluding the additional reflectance check specified in ISO/IEC 15415;
- the specification of the illumination source, including the peak light wavelength or colour temperature;
- the means of reflectance calibration;
- the means of reporting and, if available, of recording verification results;
- the optional functions which can be performed (in addition to the mandatory functions) as shown in 6.4;
- ability to average results from repeated scans;
- interfacing capabilities with other equipment, e.g. personal computer or printer;
- programming and configuration specifications.

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Annex A
(normative)

Primary reference test symbols

A.1 General requirements

Sets of primary reference test symbols shall comprise sets of symbols with varying grades for the individual parameters analysed in the ISO/IEC 15416 scan reflectance profile or the ISO/IEC 15415 image assessment. In each case the parameter value shall be sufficiently far from a grade transition to avoid introducing uncertainty, as illustrated for the various parameters in Table A.1. A recommended selection is described in the following subclauses.

A.2 Test symbols for multi-row symbologies

A.2.1 Symbologies with row crossing ability

These symbols shall be PDF417 symbols in accordance with ISO/IEC 15438, with varying parameter grades (two sets, one with X dimension 0,200 mm, the other with X dimension 0,500 mm):

- Symbol Contrast grades 4 and 1
- Modulation grades 4 and 1
- Defects (both spots and voids) grades 4 and 1
- Decodability (edge to similar edge) grades 4 and 1
- Unused error correction grades 4 and 1
- Codeword Yield grades 4 and 1

A.2.2 Symbologies without row crossing ability

Test symbols for verifiers for multi-row symbologies without row crossing capability shall be those defined in ISO/IEC 15426-1.

A.2.3 Recommended parameter values for test symbols

Table A.1 below illustrates the recommended range of values of the individual parameters which will meet the requirement stated above.

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Table A.1 — Parameter values for primary reference test symbols (multi-row symbols)

Parameter	Grade 4	Grade 1
Symbol contrast	$\geqslant$ 73,75%	25% $\leqslant$ SC $\leqslant$ 35%
Defects	$\leqslant$ 0,1375	0,2625 $\leqslant$ Defects $\leqslant$ 0,2875
Decodability	$\geqslant$ 0,65	0,28 $\leqslant$ V $\leqslant$ 0,34
Codeword Yield	$\geqslant$ 72,75%	51,75% $\leqslant$ CWY $\leqslant$ 55,25%
Unused error correction	$\geqslant$ 0,65	0,28 $\leqslant$ UEC $\leqslant$ 0,34

A.3 Test symbols for matrix symbologies

A.3.1 Test symbols for Symbol Contrast, Grid Non-uniformity and Axial Non-uniformity

Data Matrix symbols in accordance with ISO/IEC 16022, with varying parameter grades (two sets, one with X dimension 0,150 mm, the other with X dimension 0,500 mm):

- Symbol Contrast grades 4 and 1
- Grid non-uniformity grades 4 and 1
- Axial Non-uniformity grades 4 and 1

The above selection, together with the symbols described in the following sub-clauses, provides a representative set of test symbols which will enable all essential parameters to be compared as measured with the actual values certified by the supplier of the symbols and confirm conformity with this part of ISO/IEC 15426. Although it is permissible for a single symbol with all parameters graded 4 to be used in place of individual symbols for grade 4 Symbol Contrast, Grid non-uniformity etc., separate symbols shall be used to test the lower grade parameter measurements (with all parameters other than the one under test achieving grade 4).

A.3.2 Test symbols for Modulation

The test symbol for Modulation for matrix symbols is a Data Matrix ECC 200 symbol, illustrated in Figure A.1, which encodes "///00".

In the data region it contains a dark module surrounded completely by light modules, a dark widow. The dark widow is located two modules below the upper alternating finder pattern and four modules to the right of the left "L" finder pattern. The width and height of this module are each reduced to five ninths of the nominal X dimension. The X dimension shall be 0,18 mm and 0,36 mm, or similar values that enable the resolution of the generating device to create the dark widow at five ninths of the X dimension. The test symbol shall be calibrated using 0,8 X effective aperture. The tolerance on the measured modulation of the dark widow shall be +/-8% of the calibrated modulation value.

The verifier shall output modulation information so that the modulation value of the module containing the dark widow can be determined for conformance verification.

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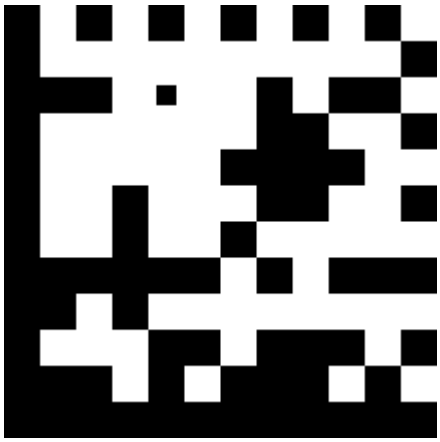

Figure A.1 — Example test symbol for Modulation

NOTE Figure A.1 illustrates the construction of the symbol but is not an accurate representation of the dimensions of the modules or defects.

A.3.3 Test symbols for Unused Error Correction

Figure A.2 shows a Data Matrix ECC 200 symbol which encodes the data "gibgibgibgibgibgibgibgibgibgibgibgibybiybiybiybiybiybiybiybi" but has had eight errors introduced by reversing the colour of a single module in each of eight codewords in the data region. The symbol has 44 data codewords and 28 error correction codewords, giving an error correction capacity of 14 errors. The errors in the symbol yield an unused error correction value of 1 – 16/28 = 0,43: a value in the grade 2 range.



Figure A.2 — Test symbol for Unused Error Correction

A.3.4 Test symbols for Fixed Pattern Damage and additional parameters

Since the evaluation of Fixed Pattern Damage varies for each symbology, and in some cases additional parameters are assessed, a separate test symbol is required for each symbology that the verifier is capable of verifying.

As examples, test symbols for Data Matrix (ISO/IEC 16022) and QR Code (ISO/IEC 18004) are defined. Figure A.3 shows a Data Matrix symbol with the damage to each of the 5 segments given in Table A.2.

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Table A.2 — Fixed Pattern Damage grading of Figure A.3

Segment	Module errors	Grade
L1	2	3
L2	4	2
QZL1	4	2
QZL2	2	3
Clock track and adjacent solid pattern	1 + 1	3
AG = 2,6		1
Therefore grade for Fixed Pattern Damage is **1**		

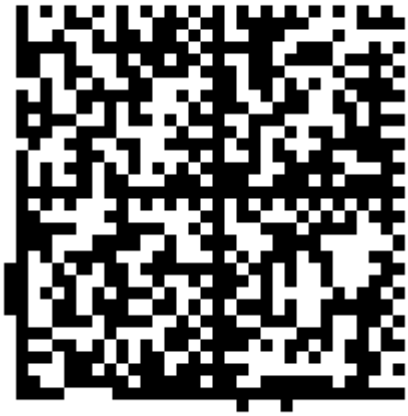

Figure A.3 — Test symbol for Fixed Pattern Damage (Data Matrix)

Figure A.4 shows a QR Code symbol with the damage to the fixed pattern segments and the Format Information given in Table A.3.

Table A.3 — Fixed Pattern Damage grading and Format Information grading of Figure A.4

Segment	Module errors (%)	Grade
A3: Lower left Position Detection Pattern	*1*	
A3: Separator	*2*	
Total for segment A3	3	1
B1	1 (5,88%)	3
B2	2 (11,76%)	1
Fixed Pattern Damage grade for symbol		**1**
Format Information 1	4	0
Format Information 2	2	2
Mean of Format Information grades		**1**

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Figure A.4 — QR Code symbol with Fixed Pattern Damage

A.3.5 Recommended parameter values for test symbols

Table A.4 below illustrates the recommended range of values of the individual parameters which will meet the requirements stated above.

Table A.4 — Parameter values for primary reference test symbols (matrix symbols)

Parameter	Grade 4	Grade 2	Grade 1
Symbol contrast	$\geqslant$ 73,75%		25% $\leqslant$ SC $\leqslant$ 35%
Grid non-uniformity	$\leqslant$ 0,35		0,66 $\leqslant$ GNU $\leqslant$ 0,72
Axial Non-uniformity	$\leqslant$ 0,055		0,105 $\leqslant$ AN $\leqslant$ 0,115
Unused error correction[a]	n/a	0,43	n/a
Fixed pattern damage[a]	AG[b] = 4		AG[b] = 2,6

[a] These values apply only to Data Matrix symbols; corresponding values for other symbologies must be derived from the UEC or Fixed Pattern Damage grading basis used for the symbology in question.

[b] AG refers to the average grade for the five Fixed Pattern segments evaluated for Data Matrix (see ISO/IEC 15415).

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Annex B
(normative)

Verification requirements for primary reference test symbols

Primary verification refers to measurement by a device that mimics the measurement methodology of typical commercial verification devices and has national standard traceable performance on the reflectance and on the linear distance axes at a magnitude of ten times better than such devices. Furthermore, a primary verification device must have demonstrable repeatability ten times better than typical commercial verification devices. The instrument generally used for primary verification of linear and multi-row bar code symbols is a high resolution scanning microdensitometer; for two-dimensional matrix symbols it is a high resolution imaging system.

Measurement of linear distance should be based on a chrome on glass linear encoder, laser interferometer, or equivalent and be traceable to a measured chrome on quartz national measurement standard. The repeatability over the same scan path of measured linear distance shall be within $\pm$ 0,5 micron worst-case element width spread over 39 elements for five scans.

For imaging systems the effective resolution of the measuring device shall be at least 6, and preferably 8 image pixels per module in each axis. In the case of the Data Matrix symbol with X = 0,150 mm this corresponds to a minimum resolution of 40 pixels/mm (1016 pixels/inch) and a preferred resolution of 53 pixels/mm (1350 pixels/inch).

Measurement of reflectance should be based on a high resolution ($\geqslant$ 10 bit) analogue-to-digital converted voltage detector of reflected light and the result should be traceable to a measured national standard reflectance tablet. Measured values of R_{max} and R_{min} shall be repeatable within $\pm$ 0,5% reflectance worst case spread for five scans over the same scan path.

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