KEYENCE

Barcode/Two-dimensional Code Verification Guide Book

CONTENTS

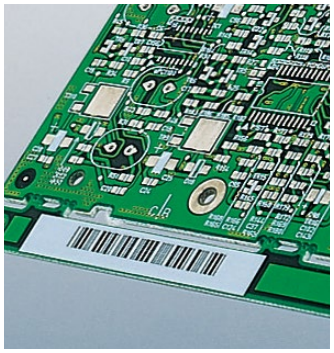
1 What is Barcode/Two-dimensional Code Verification?

“Barcode verification” refers to checking the marking quality of CODE39, CODE128, and EAN barcodes. Barcodes are used in a variety of fields such as FA, distribution, food, wholesale, and medical products.

“Two-dimensional code verification” refers to checking the marking quality of DataMatrix symbols and QR code symbols. Two-dimensional codes have spread to a wide variety of fields, and there are many cases in which the same two-dimensional code is read at multiple work sites. Examples include between automotive parts suppliers and automobile manufacturers, between medicine manufacturers and pharmacies, and between smartphone module manufacturers and assembly manufacturers.

Two-dimensional codes are marked on key parts at the part or module manufacturer and are read at the assembly manufacturer. This makes it possible to obtain information such as the product characteristics and serial number, which is put to use in maintaining production and quality.

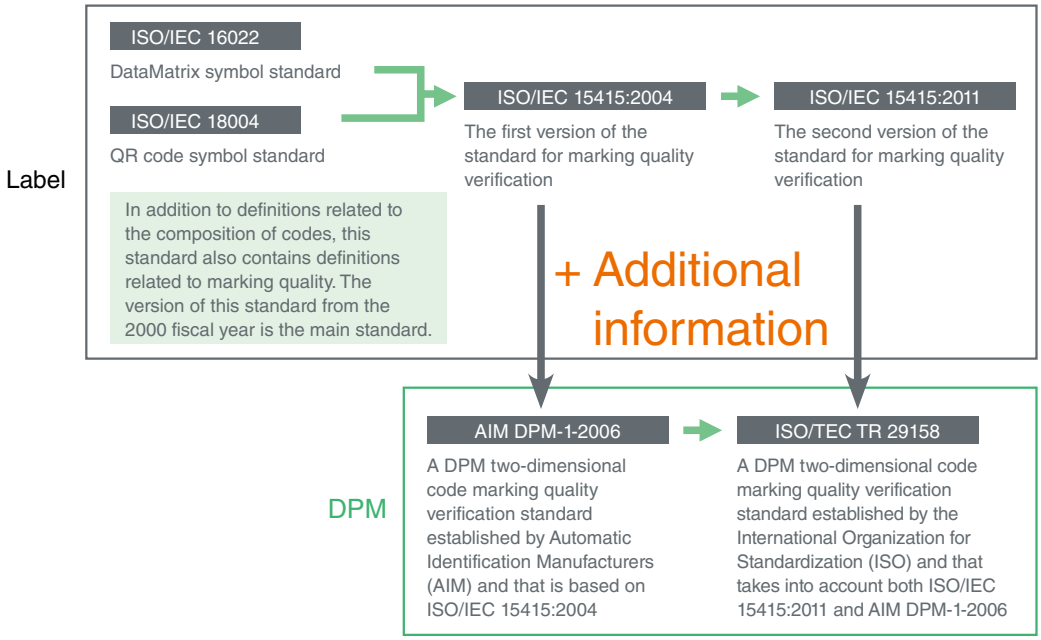
Barcodes or two-dimensional codes that are difficult to read hinder productivity. Various code verification standards have been developed as quantitative guidelines aimed at eliminating this problem.



2 Changes in Two-dimensional Code Verification

The history of two-dimensional code verification began in 2000, and the standards have been revised over time.

* The following illustration shows how code verification standards have changed from 2000 to today. As the marking target has shifted from labels (paper) to objects such as metal and resin, new standards have been created.



3 Types of Barcode/Two-dimensional Code Verification Standards

Typical code verification standards are introduced below.

ISO/IEC 15415

This is a standard for the evaluation of the marking quality of two-dimensional codes. It was established by the International Organization for Standardization (ISO). It is mainly used to evaluate two-dimensional codes marked on labels.

ISO/IEC TR 29158 (AIM DPM-1-2006)

This is a standard for the evaluation of the marking quality of two-dimensional codes in direct part marking. It was established by Automatic Identification Manufacturers (AIM). It is based on ISO/IEC 15415. It was also standardized by the ISO in 2011.

SAE AS9132

This is a standard for the evaluation of the marking quality of DataMatrix symbols used in the aerospace industry. It was established by the Society of Automotive Engineers (SAE).

SEMI T10-0701

This is a standard for the evaluation of the marking quality of DataMatrix symbols marked on materials related to semiconductors. It was established by Semiconductor Equipment and Materials International (SEMI).

ISO/IEC 15416

This is a barcode verification standard established by the International Organization for Standardization (ISO). It is mainly used to evaluate barcodes marked on labels.

4 ISO/IEC 15416 Verification Method

Within the center area that makes up 80% of the barcode (excluding the top and bottom 10%), 10 scans worth of verification data are obtained every 8%.

The grade of each scan is judged.
The range of grades is A, B, C, D, F.

Grade	Numeric value
A	4.0
B	3.0
C	2.0
D	1.0
F	0.0

The grade of each scan is converted to a numeric value according to the table on the left.

Scan	Grade	Numeric value
1	A	4.0
2	A	4.0
3	B	3.0
4	B	3.0
5	A	4.0
6	A	4.0
7	C	2.0
8	F	0.0
9	D	1.0
10	A	4.0

Average: 2.9

The average is calculated from the grades of the data from 10 scans. Then, this average is further classified into a grade according to the total grade judgment table.

In the example shown in the table on the left, the average is 2.9.

Average	ISO/IEC 15416 total grade
4.0 to 3.5	A
3.4 to 2.5	B
2.4 to 1.5	C
1.4 to 0.5	D
0.4 to 0.0	F

The total grade is determined for the calculated average according to the table on the left.

In this example, the average is 2.9, so the grade is “B.”

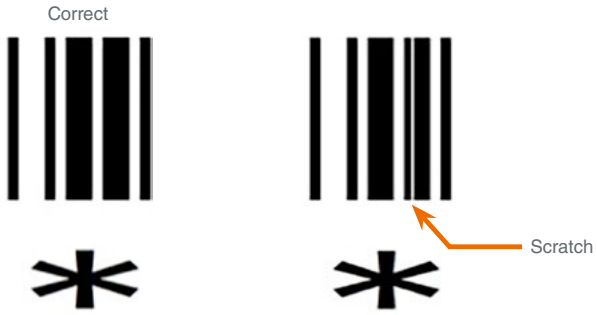
5 ISO/IEC 15416 Verification Items and their Meanings

1 DEC(Decode)

Judges whether reading is possible when decoding is performed.
If the grade of this item is low, it may not be possible to identify the barcode as such.

2 EDGE(Edge Determination)

Judges whether the read number of barcode edges (points where the color switches between white and black) equals the expected number of edges.
As shown in the bottom-right image, the inclusion of white lines due to factors such as scratches reduces the grade.



3 SC(Symbol Contrast)

Evaluates the difference between the maximum light intensity (Rmax) and the minimum light intensity (Rmin) within the code area.
If an overall contrast is not sufficient, the grade is low.

4 MINR(Minimum Reflectance)

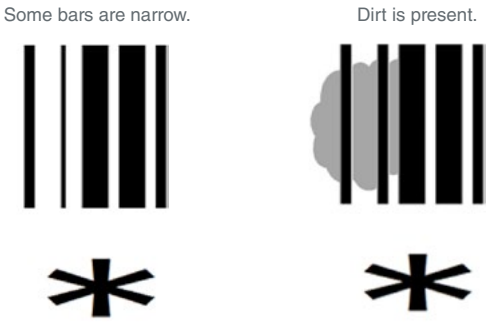
This is the minimum reflectance in the scan waveform.
Evaluates whether the minimum light intensity (Rmin) is 50% or less of the maximum light intensity (Rmax).
If the bars are marked in an overall light manner, the grade is low.

5 MINE(Minimum Edge Contrast)

Evaluates whether the minimum difference in reflectance between a space (including the quiet zone) and its neighboring bars is 15% or less.
If some bars are narrow or if part of the background is dirty, the grade is low.

6 MOD(Modulation)

Evaluates the ratio of the minimum edge contrast to the symbol contrast.
If some bars are narrow or if part of the background is dirty, the grade is low.

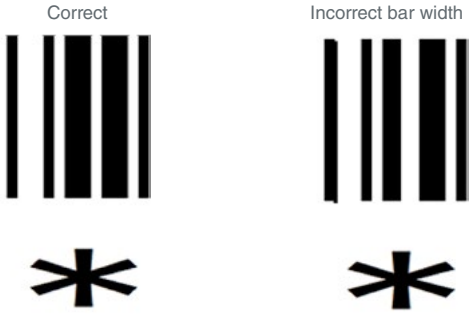


7 QZ(Quiet Zone)

Evaluates whether the quiet zone width meets the standard.

8 DCD(Decodability)

The decodability is determined for each code type. This evaluates the size of the error between the ideal line width pattern and the actual line width pattern.
If bars or spaces are too wide or too narrow, the grade is low.



9 DEF(Defects)

Evaluates uneven colors within elements.
If bars or spaces are flawed or dirty, the grade is low.

6 Barcode Verification Function Output Generated by KEYENCE Products

1 Total judgment only: Read data + total judgment

Example: 123456789:B

2 Total judgment + detailed judgment

Example: ABC12345:B/A/A/B/A/A/A/A/A/A

Verification result appending order

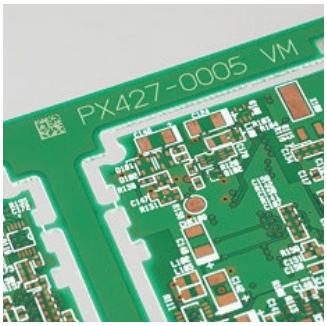
The evaluation results for each verification are arranged in the order shown below.

Standard name	Evaluation item name	Abbreviation
ISO/IEC 15416	Overall	ALL
	Decode	DEC
	Edge Determination	EDGE
	Symbol Contrast	SC
	Minimum Reflectance	MINR
	Minimum Edge Contras	MINE
	Modulation	MOD
	Quiet Zone	QZ
	Decodability	DCD
	Defects	DEF

7 What is ISO/IEC TR 29158 (AIM DPM-1-2006) Verification?

ISO/IEC TR 29158 (AIM DPM-1-2006) is a two-dimensional code marking quality verification standard that aims to verify the marking quality of “QR code symbols” and “DataMatrix symbols” marked directly on products using technology known as direct part marking (DPM).

To enable product traceability, direct part marking is used to mark automatic identification codes directly on parts such as metal parts, molds, printed circuit boards, plastic, and glass. This technology is attracting attention in industries such as the aircraft, automotive, electronic equipment, and medical equipment and materials industries.
Among all types of automatic identification codes, it has become common to use two-dimensional codes in order to encode a large amount of information in a limited amount of space. Because using two-dimensional codes makes it possible to use a large amount of information, these codes are used not only in production traceability but also in production management.



In this way, the use of DPM two-dimensional codes has spread, which has led to an increase in the reading and use of two-dimensional codes in various locations.
Hence, being unable to read codes inhibits production. As such, there is a trend toward managing the marking quality of DPM two-dimensional codes marked on parts received by manufacturers such as those in the automotive industry.
For this management, ISO/IEC TR 29158 (AIM DPM-1-2006), a marking quality verification standard for DPM two-dimensional codes, is used. Using this standard not only reduces the time and effort required to interchange separate specifications but also makes it possible to comprehensively interchange the management items related to marking specifications.

8 Main Differences between ISO/IEC TR 29158 (AIM DPM-1-2006) Verification and ISO/IEC 15415 Verification

This section explains the main differences between ISO/IEC TR 29158 (AIM DPM-1-2006) verification and ISO/IEC 15415 verification.

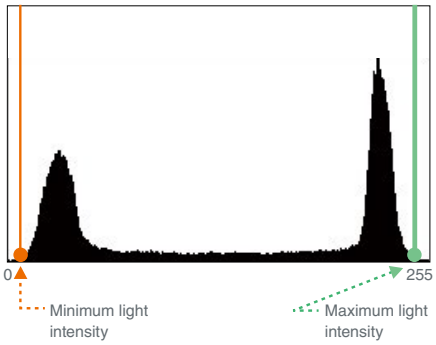
Determination of the binary processing threshold

These methods vary in the way that they determine the threshold used to judge whether a cell is white or black. The detailed difference is shown below.

ISO/IEC 15415

Figure 3-2-1

Converting the light intensity within the symbol to a histogram



ISO/IEC 15415 uses the midpoint between the maximum light intensity and minimum light intensity within the symbol as the threshold.

ISO/IEC TR 29158 (AIM DPM-1-2006)

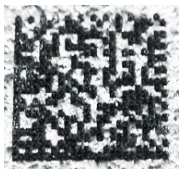
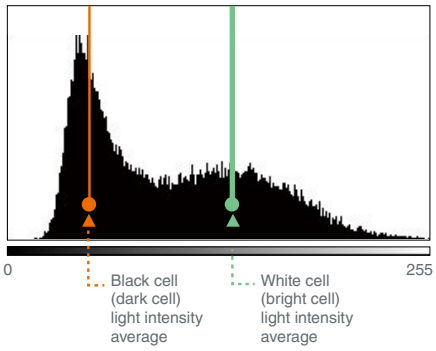


Figure 3-2-3

Converting the light intensity within the symbol to a histogram



ISO/IEC TR 29158 (AIM DPM-1-2006) uses the minimum light intensity total of the black cell and white cell light intensity distribution within the symbol as the threshold. The black cell light intensity average and the white cell light intensity average in the above graph are the values that are determined after the threshold is defined and are used in the evaluation of items such as the cell contrast.

Review

ISO/IEC 15415	Standard for verifying two-dimensional codes marked on labels
ISO/IEC TR 29158	Standard for verifying two-dimensional codes marked directly on parts

9 ISO/IEC 15415 and ISO/IEC TR 29158 Verification Items and their Meanings

As explained in the previous chapter, ISO/IEC 15415 verification and ISO/IEC TR 29158 verification vary according to their binary processing thresholds. However, the verification item details are similar, and the basic interpretation method is the same for both standards.
This section explains the meanings of the verification items and the interpretations when grades are low.

1 DEC(Decode)

Judges whether reading is possible when decoding is performed using the binary processing method in chapter 5.
If the grade of this item is low, it will not be possible to identify the two-dimensional code as such.

The following are some possible reasons for low grades.
Part of the two-dimensional code is so faint that it has almost disappeared.
Two different two-dimensional codes have been printed overlapping one another.

2 SC(Symbol Contrast) ← ISO/IEC 15415
CC(Cell Contrast) ← ISO/IEC TR 29158(AIM DPM-1-2006)

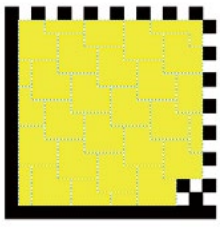
Judges the brightness difference between black and white parts within the code.
If the grade of this item is low, contrast will not be sufficient.

Items such as the way in which illumination shines on the target, the color of the illumination, and the code's coloring status can be checked.

3 MOD(Modulation) ← ISO/IEC 15415
CM(Cell Modulation) ← ISO/IEC TR 29158(AIM DPM-1-2006)

Evaluates the blocks (the yellow parts in the following figures) that compose the data within the two-dimensional code.

If the grade of this item is low, the code may be scratched or dirty.
Alternatively, the cell marking may be misaligned.



4 RM(Reflectance Margin)

This is an evaluation that adds white/black accuracy to the 6.3 MOD and CM evaluation methods.

5 FPD(Fixed Pattern Damage)

This item evaluates whether the finder pattern and the margin used to detect the two-dimensional code have been marked correctly.

This item has a stricter judgment criteria than the other items. Its grade is lowered easily by scratches and dirt.
For example, marking characters immediately next to a QR code often leads to this item having a grade of F.

Evaluation locations: The targets are the yellow cells.

DataMatrix symbol, FPD evaluation with 5 items

Left Alignment Pattern (LAP)

Figure 3-4-5-1-1

Bottom Alignment Pattern (BAP)

Figure 3-4-5-1-2

Left Quiet Zone (LQZ)

Figure 3-4-5-1-3

Bottom Quiet Zone (BQZ)

Figure 3-4-5-1-4

Timing Pattern and Touching Quiet Zone (TP & TQZ)

Figure 3-4-5-1-5

QR code symbol, FPD evaluation with 6 items

Upper Left Finder Pattern (ULP)

Figure 3-4-5-2-1

Upper Right Finder Pattern (URP)

Figure 3-4-5-2-2

Lower Left Finder Pattern (LLP)

Figure 3-4-5-2-3

Horizontal Timing Pattern (HCT)

Figure 3-4-5-2-4

Vertical Timing Pattern (VCT)

Figure 3-4-5-2-5

Alignment Pattern (ALP)

Figure 3-4-5-2-6

6 FID(Format Information Damage)

This evaluation item is only used with QR codes. It has information related to the error correction level and mask pattern of the QR code. If this item is dirty, it will not be possible to read the code.

QR code symbol

Figure 3-4-6-1

7 VID(Version Information Damage

This evaluation item is only used with QR codes that are model 2, version 7 or later.

QR code symbol, version 7

Figure 3-4-7-1

8 AN(Axial Nonuniformity)

Evaluates whether the cells are marked correctly as squares from the cell placement positions in the horizontal and vertical directions.

The grade of this item is low in situations such as when the marking speed of the printer and the paper feed speed are not aligned.

Evaluation method

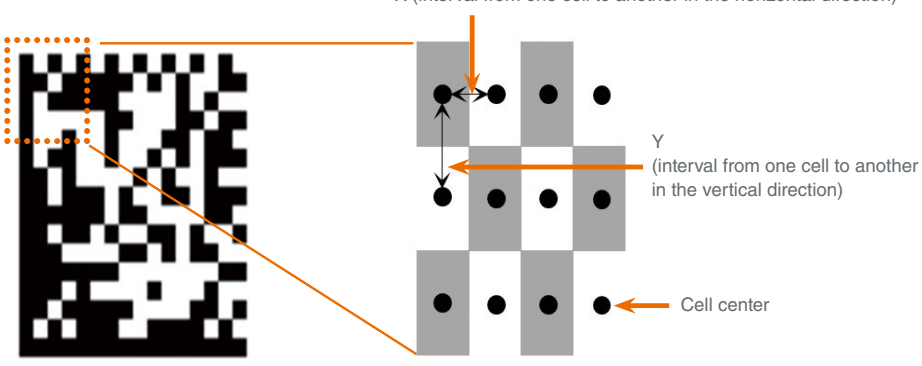


Figure 3-4-8-1

9 GN(Grid Nonuniformity)

Evaluates whether the cell's center position is offset from the ideal position.
If the cell position is offset during marking due to factors such as device vibrations, the grade of this item will be low.

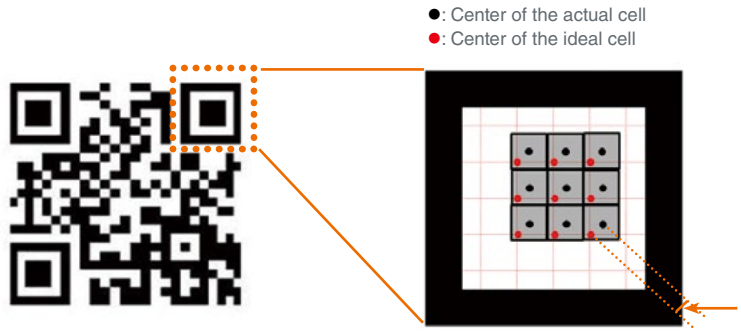


Figure 3-4-6-1
Offset between the actual cell and the ideal cell

10 UEC(Unused Error Correction)

Evaluates how much of the error correction capability possessed by the two-dimensional code has been used.
The grade of this item being low indicates that a large amount of the error correction capability has been used.

The two-dimensional code may be dirty or worn.

11 PGH(Print Growth Horizontal)

This item evaluates the expansion and contraction of the black and white cells in the horizontal direction.

The grade of this item is lowered by factors such as bleeding during marking.

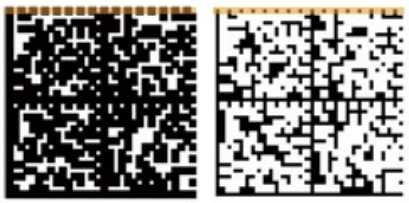


Figure 3-4-11-1

12 PGV(Print Growth Vertical)

This item evaluates the expansion and contraction of the black and white cells in the vertical direction.

The grade of this item is lowered by factors such as bleeding during marking.

Figure 3-4-11-2

10 Two-dimensional Code Verification Function Output Generated by KEYENCE Products

1 Total judgment only: Read data + total judgment

Example: 123456789:B

2 Total judgment + detailed judgment

Example: ABC12345:B/A/A/B/B/A/-/-/A/A/A/A/A

The total judgment is the lowest evaluation in the detailed judgment.

* The print growth items (PGH and PGV) are not included in the total judgment.
Also, in the case of DataMatrix codes, the FID and VID items are targets, so they are recorded as "---."

Verification result appending order

The evaluation item results for each verification are arranged in the order shown below.

Standard name	Evaluation item name	Abbreviation
ISO/IEC 15415	Overall	ALL
	Decode	DEC
	Symbol Contrast	SC
	Modulation	MOD
	Reflectance Margin	RM
	Fixed Pattern Damage	FPD
	Format Information Damage	FID *1
	Version Information Damage	VID *2
	Axial Nonuniformity	AN
	Grid Nonuniformity	GN
	Unused Error Correction	UEC
	Print Growth Horizontal	PGH
	Print Growth Vertical	PGV

Standard name	Evaluation item name	Abbreviation
ISO/IEC TR 29158 (AIM DPM-1-2006)	Overall	ALL
	Decode	DEC
	Cell Contrast	CC
	Cell Modulation	CM
	Reflectance Margin	RM
	Fixed Pattern Damage	FPD
	Format Information Damage	FID *1
	Version Information Damage	VID *2
	Axial Nonuniformity	AN
	Grid Nonuniformity	GN
	Unused Error Correction	UEC
	Print Growth Horizontal	PGH
	Print Growth Vertical	PGV

*1 This is only valid for QR and Micro QR codes. In the case of DataMatrix codes, "-" is displayed.
*2 This is only valid for QR codes that are model 2, version 7 or later. For all other codes, "-" is displayed.

11 GS1 DataMatrix

GS1 DataMatrix is a two-dimensional code symbol that is a standardized version of GS1* for use in distribution. The symbol system is based on DataMatrix ECC200, and the rules shown below have been defined in order to distinguish these codes from conventional DataMatrix codes.

* GS1 = An international organization related to supply chains.

Main details of GS1 DataMatrix

Code used	DataMatrix ECC200
FNC1	[FNC1] is placed at the head of the data to define it as using the standard GS1 specifications.
Application identifier (AI)	This is an identification code that is added at the head of the information to ensure that anyone can understand what information is provided by the data that follows the identification code. The application identifier (AI) is prescribed in ISO/IEC 15418.
Handling variable-length data	When displaying the next block of data after data (variable-length data) whose amount of information varies, such as a quantity, insert [FNC1] as a delimiter character string after the variable-length data. When this [FNC1] is read by a code reader, the output is prescribed to be [GS] (“1Dh” in ASCII code). * [GS]: Group separator

Marking cell sizes recommended by GS1

With GS1 DataMatrix, the following marking cell sizes are recommended by GS1.

	Recommended cell size	Maximum cell size	Minimum cell size
Label marking	0.300 mm	0.615 mm	0.255 mm
DPM	0.380 mm	0.495 mm	0.380 mm

GS1 DataMatrix sample

Category	AI	Data
GTIN (fixed to 14 digits)	01	04912345678904
Quantity (variable length)	30	100
Warranty expiration date	17	120401

Recommended code verification grade

To ensure stable reading, the general recommendation is to maintain a total grade of C or higher for the different standards.

Supported verification standards

Label marking	ISO/IEC 15415
DPM	ISO/IEC TR 29158

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