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Information technology — Automatic identification and data capture techniques — Code 39 bar code symbology specification

Technologies de l'information — Techniques d'identification automatique et de capture des données — Spécifications des symbologies des codes à barres, code 39

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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.

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ISO/IEC 16388 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 31, *Automatic identification and data capture techniques*.

This second edition cancels and replaces the first edition (ISO/IEC 16388:1999), which has been technically revised.

Introduction

The technology of bar coding is based on the recognition of patterns encoded in bars and spaces of defined dimensions. There are numerous methods of encoding information in bar code form, known as symbologies. Code 39 is one such symbology. The rules defining the translation of characters into bar and space patterns and other essential features are known as the symbology specification.

In the past, symbology specifications were developed and published by a number of organizations, resulting in certain instances in conflicting requirements for certain symbologies.

Manufacturers of bar code equipment and users of bar code technology require publicly available standard symbology specifications to which they can refer when developing equipment and application standards.

Information technology — Automatic identification and data capture techniques — Code 39 bar code symbology specification

1 Scope

This International Standard specifies the requirements for the bar code symbology known as Code 39; it specifies Code 39 symbology characteristics, data character encodation, dimensions, tolerances, decoding algorithms and parameters to be defined by applications. It specifies the Symbology Identifier prefix strings for Code 39 symbols.

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/IEC 646, *Information technology — ISO 7-bit coded character set for information interchange*

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

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

ISO/IEC 19762-1, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 1: General terms relating to AIDC*

ISO/IEC 19762-2, *Information technology — Automatic identification and data capture (AIDC) techniques — Harmonized vocabulary — Part 2: Optically readable media (ORM)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 19762-1 and ISO/IEC 19762-2 apply.

4 Requirements

4.1 Symbology characteristics

The characteristics of Code 39 are as follows.

a) Encodable character set:

   1) full alphanumeric A to Z and 0 to 9 (ASCII characters 65 to 90 and 48 to 57 inclusive, in accordance with ISO 646).

2) special characters: space $ % + - . / (ASCII characters 32, 36, 37, 43, 45, 46 and 47, respectively, in accordance with ISO 646).

3) start/stop character.

b) Code type: discrete.

c) Elements per symbol character: 9, of which 3 wide and 6 narrow, comprising 5 bars and 4 spaces.

d) Character self-checking: yes.

e) Data string length encodable: variable.

f) Bidirectionally decodable: yes.

g) Symbol check character: one, optional (see Annex A).

h) Symbol character density: 13 to 16 modules per symbol character, inclusive of minimum intercharacter gap, depending on wide/narrow ratio.

i) Non-data overhead: equivalent to 2 symbol characters.

4.2 Symbol structure

As illustrated in Figure 1, Code 39 symbols shall comprise

a) leading quiet zone;

b) start character;

c) one or more symbol characters representing data (including symbol check character, if present);

d) stop character;

e) trailing quiet zone.

A space, the intercharacter gap, shall separate characters within the symbol.

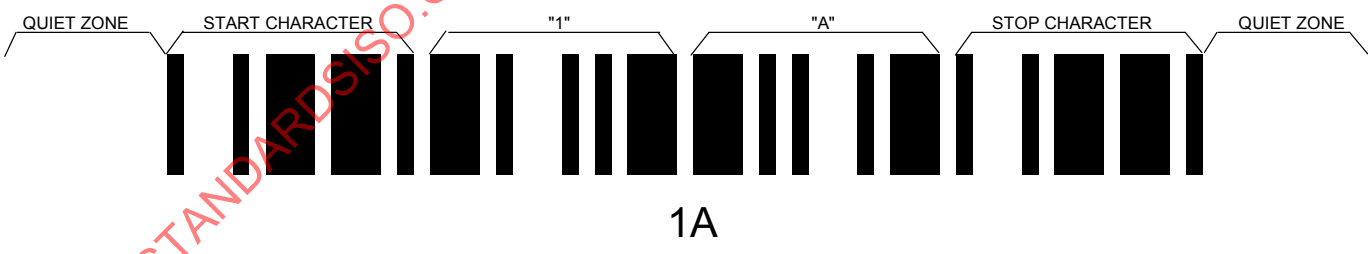

Figure 1 — Code 39 symbol

4.3 Character encodation

4.3.1 Symbol character structure

Each symbol character comprises nine elements (five bars and four spaces) of which six are always narrow (either three narrow bars and three narrow spaces, or five narrow bars and one narrow space) and three are always wide (one wide space and two wide bars when there are three narrow bars, or three wide spaces when there are five narrow bars). This parity feature enables character self-checking to be carried out.

4.3.2 Symbol character assignments

Table 1 defines all the Code 39 character assignments.

Table 1 — Code 39 character assignments

Char.	Encodation Pattern	B	S	B	S	B	S	B	S	B	ASCII value
0		0	0	0	1	1	0	1	0	0	48
1		1	0	0	1	0	0	0	0	1	49
2		0	0	1	1	0	0	0	0	1	50
3		1	0	1	1	0	0	0	0	0	51
4		0	0	0	1	1	0	0	0	1	52
5		1	0	0	1	1	0	0	0	0	53
6		0	0	1	1	1	0	0	0	0	54
7		0	0	0	1	0	0	1	0	1	55
8		1	0	0	1	0	0	1	0	0	56
9		0	0	1	1	0	0	1	0	0	57
A		1	0	0	0	0	1	0	0	1	65
B		0	0	1	0	0	1	0	0	1	66
C		1	0	1	0	0	1	0	0	0	67
D		0	0	0	0	1	1	0	0	1	68
E		1	0	0	0	1	1	0	0	0	69
F		0	0	1	0	1	1	0	0	0	70
G		0	0	0	0	0	1	1	0	1	71
H		1	0	0	0	0	1	1	0	0	72
I		0	0	1	0	0	1	1	0	0	73
J		0	0	0	0	1	1	1	0	0	74
K		1	0	0	0	0	0	0	1	1	75
L		0	0	1	0	0	0	0	1	1	76
M		1	0	1	0	0	0	0	1	0	77
N		0	0	0	0	1	0	0	1	1	78
O		1	0	0	0	1	0	0	1	0	79
P		0	0	1	0	1	0	0	1	0	80
Q		0	0	0	0	0	0	1	1	1	81
R		1	0	0	0	0	0	1	1	0	82
S		0	0	1	0	0	0	1	1	0	83

Char.	Encodation Pattern		B	S	B	S	B	S	B	S	B	ASCII value
T			0	0	0	0	1	0	1	1	0	84
U			1	1	0	0	0	0	0	0	1	85
V			0	1	1	0	0	0	0	0	1	86
W			1	1	1	0	0	0	0	0	0	87
X			0	1	0	0	1	0	0	0	1	88
Y			1	1	0	0	1	0	0	0	0	89
Z			0	1	1	0	1	0	0	0	0	90
hyphen			0	1	0	0	0	0	1	0	1	45
period			1	1	0	0	0	0	1	0	0	46
space			0	1	1	0	0	0	1	0	0	32
$			0	1	0	1	0	1	0	0	0	36
/			0	1	0	1	0	0	0	1	0	47
+			0	1	0	0	0	1	0	1	0	43
%			0	0	0	1	0	1	0	1	0	37
S/S or *			0	1	0	0	1	0	1	0	0	none

NOTE 1 S/S denotes the start and stop character, usually graphically represented as *

NOTE 2 In the columns headed B and S, 0 represents a narrow element and 1 a wide element.

4.3.3 Start and stop characters

The Code 39 start and stop character is usually depicted in human-readable form by a * (asterisk). This character shall not form part of the data encoded elsewhere in the symbol and shall not be transmitted by the decoder.

The start character shall be positioned at the normal left end of the data symbol characters, separated from the first bar of the leading data character by an intercharacter gap. The stop character shall be positioned at the normal right end of the data symbol characters (including symbol check character if present), separated from the final bar of the trailing data character by an intercharacter gap.

4.3.4 Optional symbol check character

Annex A defines the symbol check character position and calculation.

4.4 Dimensions

Code 39 symbology shall use the following nominal dimensions.

a) Width of narrow element (*X*): the *X* dimension of Code 39 symbols should be defined by the application specification having due regard to the availability of equipment for the production and reading of symbols and complying with the general requirements of the application. See 4.7.1.

b) Wide/narrow ratio (*N*): 2,0 : 1 to 3,0 : 1.

c) Width of intercharacter gap (*I*):

1) minimum: equal to *X*;

2) maximum:

for $X < 0{,}287$ mm: $5{,}3X$;

for $X \geq 0{,}287$ mm: 1,52 mm or $3X$, whichever is greater.

d) Minimum width of quiet zone: $10X$.

e) Recommended minimum bar code height for manual scanning: 5,0 mm or 15 % of symbol width excluding quiet zones, whichever is greater.

NOTE The width, *W* (in millimetres), of a Code 39 symbol, including quiet zones, can be calculated from the following expression:

$$W = (C + 2)(3N + 6)X + (C + 1)I + 2Q$$

where

W is the symbol width;

C is the number of data characters (including symbol check character if used);

N is the wide/narrow ratio;

X is the width of a narrow element in millimetres;

I is the width of the intercharacter gap in millimetres;

Q is the width of the quiet zone in millimetres.

4.5 Reference decode algorithm

Bar code reading systems are designed to read imperfect symbols to the extent that practical algorithms permit. This section describes the reference decode algorithm used in the computation of the decodability value described in ISO/IEC 15416.

a) Confirm presence of a leading quiet zone.

b) For each symbol character (including start and stop characters):

1) Measure the total width of 5 bars and 4 spaces; call this *S*.

2) Compute a threshold value, $T = S / 8$.

3) Compare each element width for that character with the value *T*. If element width is greater than *T*, assume element is wide; if not, assume element is narrow.

4) Determine if pattern of wide and narrow elements matches a valid character from the allowable set.

c) The first symbol character read must be a start/stop character, from which the scan direction can be deduced.

d) Continue character reading until a valid start/stop character is encountered.

e) Confirm presence of a trailing quiet zone.

4.6 Symbol quality

4.6.1 Test specification

In order to verify whether a symbol meets the specifications in this International Standard it shall be tested using the test specification defined in ISO/IEC 15416, which defines a standardized methodology for measuring and grading bar code symbols, as supplemented in 4.6.2. ISO/IEC 15416 lays down conditions under which measurements should be made; and defines methods of determining an overall quality grade based on the attributes of the bar code symbol. The reference decode algorithm defined in 4.5 shall be used for the assessment of the "decode" and "decodability" parameters under ISO/IEC 15416.

The overall symbol grade shall be expressed in the form shown in the following example:

1,5 / 10 / 660

where

1,5 is the overall symbol quality grade;

10 is the measuring aperture reference number (in this example 0,25 mm diameter);

660 is the peak response wavelength in nanometres.

ISO/IEC 15416 allows for additional pass/fail criteria to be stipulated by a symbology specification. For Code 39, the additional criteria are given in 4.6.2. Any individual scan profile which does not meet these requirements shall receive a grade of 0.

4.6.2 Additional parameters

4.6.2.1 Wide/narrow ratio

Symbols shall be produced with a nominal N from 2,0 to 3,0 inclusive. The measured value of N in any scan profile shall be in the range 1,8 to 3,4 inclusive. The wide/narrow ratio in the scan reflectance profile under ISO/IEC 15416 shall be measured and graded as follows.

$1{,}8 \leq N \leq 3{,}4$: Grade 4.

$N < 1{,}8$ or $N > 3{,}4$: Grade 0.

4.6.2.2 Intercharacter gap

For symbols with a measured narrow element width (Z) less than 0,287 mm, the maximum allowed intercharacter gap is 5,3Z. For symbols with Z greater than or equal to 0,287 mm, the maximum intercharacter gap is the greater of 3Z or 1,52 mm. Each intercharacter gap in the scan reflectance profile under ISO/IEC 15416 shall be measured and graded as follows.

$I \leq G_{max}$: Grade 4.

$I < G_{max}$: Grade 0.

where

$G_{max} = 5{,}3Z$ for $Z < 0{,}287$ mm or $G_{max} = \text{MAX}(1{,}52 \text{ mm}, 3Z)$ for $Z \geq 0{,}287$ mm

4.6.2.3 Quiet zone

The quiet zone at each end of the symbol shall be a minimum of 10Z. Both left and right quiet zones on each scan reflectance profile under ISO/IEC 15416 shall be measured and graded as follows.

Quiet Zone ≥ 10*Z*: Grade 4.

Quiet Zone < 10*Z*: Grade 0.

NOTE In 4.6.2.1 to 4.6.2.3, the requirements are based on the actual, rather than intended, measurements of the parameter; for this reason the *Z* dimension is appropriate rather than the *X* dimension.

4.7 Application-defined parameters

4.7.1 Symbology and dimensional characteristics

In order for a Code 39 symbol to be printed and to be scannable in a given application it is necessary for the following symbology and dimensional parameters to be specified by the application specification:

a) selection of subset of the encodable character set;

b) the number of data characters in the symbol, which may be fixed, variable or variable up to a defined maximum;

c) whether the modulo 43 symbol check character is to be used (see A.1) and whether it is to be transmitted by the decoder;

d) whether a data check character is to be used and if so the algorithm for its calculation;

e) range of *X* dimension;

f) range of wide/narrow ratio;

g) intercharacter gap;

h) minimum bar height.

NOTE 1 For applications wishing to take advantage of enhanced data security, a symbol check character should be used.

NOTE 2 The wide/narrow ratio should be as high as possible within the range specified in 4.4 to maximize reading performance.

An example is given in Annex D.

4.7.2 Optical specifications

In order for a bar code symbol to be scannable in a given application, it is necessary to specify certain optical parameters. The selection of the parameters shall be made in the application standard and shall include the specification of

— peak response wavelength;

— spectral half power band width with which the symbol and the scanner should conform;

— the spot size of the scanner;

— the parameters for reflectance of the bars and spaces;

— the conditions under which optical measurements should be made;

— the extent of permissible imperfections within the bar code symbol.

An example is provided in Annex D.

4.7.3 Test specifications

Application specifications should define the minimum overall symbol grade for acceptability (including minimum grade level, required measurement aperture and peak response wavelength) when symbols are measured in accordance with ISO/IEC 15416.

Annex A
(informative)

Additional features

A.1 Check character

A.1.1 Symbol check character

For applications requiring enhanced data security, a symbol check character should be used, in which case the symbol check character should be positioned immediately following the final data character and before the stop character. The inclusion of the symbol check character should be determined by the application standard.

When included, the following symbol check character algorithm should be used.

a) Each data character is assigned a numerical value as shown in Table A.1 below.

b) Calculate the sum of the numerical values for all the data characters of a symbol.

c) Divide this sum by 43.

d) The character whose value (from Table A.1) is the remainder from the division in step c) is used as the check character.

Table A.1 — Numerical character values for modulo 43 check

Character	Value	Character	Value	Character	Value
0	0	F	15	U	30
1	1	G	16	V	31
2	2	H	17	W	32
3	3	I	18	X	33
4	4	J	19	Y	34
5	5	K	20	Z	35
6	6	L	21	-	36
7	7	M	22	.	37
8	8	N	23	SPACE	38
9	9	O	24	$	39
A	10	P	25	/	40
B	11	Q	26	+	41
C	12	R	27	%	42
D	13	S	28		
E	14	T	29		

The modulo 43 symbol check character may be transmitted by the decoder.

EXAMPLE For the data "CODE 39":

Data characters	**C**	**O**	**D**	**E**	**SPACE**	**3**	**9**	
Character values	12	24	13	14	38	3	9	
Sum of values	113							
Divide by 43		113/43 = 2		remainder 27				
Character value 27 corresponds to	R							
Data with symbol check character	**C**	**O**	**D**	**E**	**SPACE**	**3**	**9**	**R**

A.1.2 Data check character

When transmitted by the decoder, the modulo 43 check character may be used as a data check character.

Alternatively, an algorithm as described in ISO 7064, or another algorithm defined in the application specification, may be used to calculate a data check character, provided that suitable provision for its calculation and verification is included in the symbol generation and message processing software. Such a data check character should be the final character of the data string and shall be transmitted by the decoder.

A.2 Human-readable interpretation

A human-readable interpretation of the data characters (and data and symbol check character(s), if used) should normally be printed with the Code 39 symbol encoding them. Start/stop characters may be printed. Character size and font are not specified, and the interpretation may be printed anywhere in the area surrounding the symbol, as long as quiet zones are not encroached upon.

A.3 Optional data transmission modes

Decoders may be programmed to respond to Code 39 symbols in non-standard ways to satisfy particular application requirements. Three such schemes are defined below: full ASCII (see A.3.1), message append (see A.3.2) and control functions (see A.3.3). Since the use of these features requires special decoder programming, they are not recommended for general applications, where there could be confusion with standard Code 39 symbols.

A.3.1 Full ASCII

The full 128 character ASCII character set in accordance with ISO 646 IRV (including the C0 set of control characters defined in ISO/IEC 6429 with values 28 – 31 modified to FS, GS, RS and US respectively) may be encoded using either one or combinations of two symbol characters, made up of one of the four characters ($ + % /) followed by one of the 26 alphabetic characters. These combinations are shown in Table A.2. When the full ASCII option is enabled in the decoder, only the ASCII equivalent of the symbol character combinations and not their literal translation should be transmitted.

A.3.2 Message append

It is sometimes advantageous to break up long messages into multiple shorter symbols. If the first data character of a Code 39 symbol is a 'space', the decoder may be programmed to append the information contained in the remainder of the symbol to a storage buffer (data not transmitted). This operation continues for all successive Code 39 symbols with a leading 'space', with messages being added to the end of previously stored ones. When a message is read which does not contain a leading 'space', the contents are appended to the buffer, the entire buffer is transmitted, and the buffer is cleared. Where the sequence of data is significant, the application should make provisions to ensure reading of the symbols in the correct sequence.

A.3.3 Control functions

An additional system-specific mode is also available, which may be used for closed systems but shall not be used in open systems. By using combinations of two symbol characters from the set ($ % + - . /) (ASCII characters 36, 37, 43, 45, 46, 47), 36 control functions may be programmed into a system. Decoders may be specially programmed to respond to these symbols and perform the defined functions. The literal translation of these character pairs shall not be transmitted and the symbology identifier (see Annex C) shall not be used.

Table A.2 — Encoding the Full ASCII character set in Code 39

ASCII	CODE	ASCII	CODE	ASCII	CODE	ASCII	CODE
NUL	%U	SP	SPACE	@	%V	'	%W
SOH	$A	!	/A	A	A	a	+A
STX	$B	"	/B	B	B	b	+B
ETX	$C	#	/C	C	C	c	+C
EOT	$D	$	/D	D	D	d	+D
ENQ	$E	%	/E	E	E	e	+E
ACK	$F	&	/F	F	F	f	+F
BEL	$G	'	/G	G	G	g	+G
BS	$H	(	/H	H	H	h	+H
HT	$I	)	/I	I	I	i	+I
LF	$J	*	/J	J	J	j	+J
VT	$K	+	/K	K	K	k	+K
FF	$L	,	/L	L	L	l	+L
CR	$M	-	-	M	M	m	+M
SO	$N	.	.	N	N	n	+N
SI	$O	/	/O	O	O	o	+O
DLE	$P	0	0	P	P	p	+P
DC1	$Q	1	1	Q	Q	q	+Q
DC2	$R	2	2	R	R	r	+R
DC3	$S	3	3	S	S	s	+S
DC4	$T	4	4	T	T	t	+T
NAK	$U	5	5	U	U	u	+U
SYN	$V	6	6	V	V	v	+V
ETB	$W	7	7	W	W	w	+W
CAN	$X	8	8	X	X	x	+X
EM	$Y	9	9	Y	Y	y	+Y
SUB	$Z	:	/Z	Z	Z	z	+Z
ESC	%A	;	%F	[	%K	{	%P
FS	%B	<	%G	\	%L	|	%Q
GS	%C	=	%H	]	%M	}	%R
RS	%D	>	%I	^	%N	~	%S
US	%E	?	%J	_	%O	DEL	%T or %X or %Y or %Z

Annex B
(informative)

Guidelines for the use of Code 39

B.1 Autodiscrimination compatibility

Code 39 may be read by suitably programmed bar code decoders which have been designed to autodiscriminate it from other symbologies.

The decoder's valid set of symbologies should be limited to those needed by a given application to maximize reading security.

When Code 39 is used in an autodiscrimination environment with Interleaved 2 of 5 symbols, the following guidelines shall be followed:

a) The nominal intercharacter gaps in the Code 39 symbols shall be no wider than the narrow elements.

b) The reading system shall be constrained and the decoder programmed to ensure that the number of characters (including start and stop characters) in all Code 39 symbols is greater than one-half of the number of data characters in the Interleaved 2 of 5 symbols.

c) Interleaved 2 of 5 symbols shall have a minimum length of six characters in environments where they are autodiscriminated with Code 39.

The use of fixed length symbols, bearer bars and check characters with the Interleaved 2 of 5 symbols as recommended in ISO/IEC 16390 provides additional protection in an autodiscrimination environment.

B.2 System considerations

It is important that the various components (printers, labels, scanners) making up a bar code installation operate together as a system. A failure in any component, or a mismatch between them, can compromise the performance of the overall system. The characteristics of the printer, symbol and scanner should be matched to achieve the desired performance.

B.3 Printing considerations

B.3.1 Pixel-based printing

Graphics software used to create bar codes on pixel-based printers must scale each bar and space exactly to the pixel pitch of the printer being used, irrespective of the symbology. For two-width symbologies like Code 39 the number of pixels comprising narrow bar and space elements, before any compensation for bar width growth or loss, shall be a fixed and constant integer, and the number of pixels comprising wide elements, before any compensation for bar width growth or loss, shall be the integer product of the number of pixels in the narrow element multiplied by the wide:narrow ratio. The width of any required inter-character gap shall also be a fixed integer number of pixels. Therefore, a given printer can only print a certain set of *X* dimensions and wide:narrow ratios.

Compensation for uniform bar width growth (or loss) must be in equal offsetting amounts on all bars and spaces in the symbol. This may be accomplished by changing an integer number of pixels from dark to light or light to dark in the same manner for each bar-space pair in the symbol and for the last bar in the symbol. For

example, all pixels along the same edge of every bar in the symbol could be changed from dark to light, or pixels along both edges of every bar in the symbol could be changed from dark to light, provided that the printer resolution is sufficient to allow this to be performed satisfactorily. Any set of dark to light or light to dark pixel changes is acceptable provided the adjustment is performed consistently across the whole symbol and does not change the total symbol character width. Failure to follow these principles results in degraded symbol quality and often results in unreadable symbols.

General purpose printing software designed to support a wide range of printers should provide the user with the capability of adjusting the *X* dimension and bar width growth or loss.

Programmer's Example

These principles can be reduced to the following rules for digital bar code design files:

a) Convert the desired magnification or *X* dimension to a narrow element width in pixels rounded down to the nearest integer and select a wide:narrow ratio that will result in an integer number of pixels in the wide elements.

b) Determine the number of pixels corresponding to the desired compensation for uniform bar width growth and round up to the next larger integer.

c) Apply the above results to determine the pixel count of every bar and space in the symbol.

EXAMPLE

Using digital bar code design files with a printing device with 24 dots per mm, create a 0,27 mm *X* dimension symbol with 2,5 : 1 wide:narrow ratio and with 0,06 mm of bar width reduction.

— The narrow element size is 24 dots/mm × 0,27 mm = 6,5 pixels, which is rounded down to 6 pixels per narrow element.

— The wide element size is therefore 6 x 2,5 = 15 pixels.

— The bar growth compensation is 0,06 mm × 24 pixels/mm = 1,4 pixels, which is rounded up to 2 pixels.

This process results in the following pixel count for bars and spaces as illustrated in Table B.1.

Table B.1 — Correcting Pixels for Imaging Resolution and Bar Width Reduction

	Pixel Count	
	Bars	Spaces
Narrow elements	4	8
Wide elements	13	17

B.3.2 Guidance to users of pixel-based printing software

When printing a symbol for the first time on a printing system consisting of the bar code printing software and the printing device, a user should verify according to ISO/IEC 15416 that the printed symbol meets the required print quality grade and *X* dimension. If the resulting symbol does not achieve the required symbol quality grade the user may need to increase the *X* dimension or change the bar width growth or loss. If the *X* dimension is increased the user should verify that the minimum quiet zones are maintained. This process may need to be repeated until the required symbol grade is achieved. Not all printing systems are capable of producing acceptable symbols at small *X* dimensions.

B.3.3 Process control considerations

For process control purposes, the assessment of average bar width gain or loss, and the application of corrective action to reduce this, are appropriate. The "decodability" parameter measured in accordance with ISO/IEC 15416 is affected by systematic bar width gain or loss.