Code 16K

Specification for Barcode Symbology

1.0 Introduction

Conventional bar code symbols represent information in a single row of variable width bars and spaces. Most bar code applications are well served by one of these conventional symbologies.

Code 16K is a multi-row symbology. Multi-row symbologies are useful in applications where a large amount of data needs to be encoded in a small area and where a conventional bar code symbol cannot be applied.

Code 16K is a multi-row variable length symbology encoding the full ASCII 128-character set. It employs existing UPC and Code 128 character set patterns. Up to 77 full ASCII characters or 154 numeric characters can be encoded in a 16-row symbol. It has row identification by unique start/stop patterns, character self checking and two modulo 107 symbol check characters. The main characteristics of Code 16K are summarized in Table 1.

Encodable Character Set	All 128 ASCII Characters 4 Non-Data Function Characters 3 Code Set Change Characters 7 Shift Characters 1 Pad/Message Separator Character
Code Type	Mullti-Row, Continuous
Character Self Checking	Yes
Row Self Checking	Yes
Symbol Width	81X with Quiet Zones
Symbol Height	Variable (2 to 16 Rows)
Bidirectional Decoding	Yes
Number of Required Check Characters	2
Smallest Nominal Element	0.0075 inch (0.191 mm)
Data Capacity	2 row symbol 7 Printable ASCII, 14 numeric 16 row symbol 77 Printable ASCII, 154 numeric

Table 1
Characteristics of Code 16K

2.0 SYMBOL DESCRIPTION

2.1 Symbol Structure

Each Code 16K symbol consists of 2 to 16 rows. Each row consists of a leading quiet zone, a start character, a 1X guard bar (where X is the nominal width of a narrow bar or space), five symbol characters, a stop character, a trailing quiet zone. Rows may be separated from each other by a 1-module high separator bar. The top and bottom of the symbol also have separator bars which extend to the ends of the quiet zones.

The symbol characters are ordered from the leftmost character of the first row, through each row left to right, to the rightmost character in the last row. The first symbol character is the mode character. The last two characters are check characters. The remaining symbol characters encode the data for the symbol.

Figure 1 illustrates a complete Code 16K symbol encoding the data "ab0123456789"

Figure 1
Code 16K Symbol Encoding "ab0123456789"

2.2 Symbol Character Encodation

There are 107 Code 16K symbol characters. Each symbol character consists of eleven 1X-wide modules. Each symbol character is comprised of three spaces alternating with three bars, starting with a space. Each bar or space may consist of 1 to 4 modules.

Symbol character parity is defined by the sum of the bar modules in any symbol character. Code 16K employs odd parity for all symbol characters. Figure 2 illustrates the symbol character "A".

Code 16K has three unique data character sets, shown in Table 2 as Code Sets A,

Value	Code Set A	Code Set B	Code Set C	Pattern s b s b s b
0	SP	SP	00	2 1 2 2 2 2
1	!	!	01	2 2 2 1 2 2
2	"	"	02	2 2 2 2 2 1
3	#	#	03	1 2 1 2 2 3
4	$	$	04	1 2 1 3 2 2
5	%	%	05	1 3 1 2 2 2
6	&	&	06	1 2 2 2 1 3
7	'	'	07	1 2 2 3 1 2
8	(	(	08	1 3 2 2 1 2
9	)	)	09	2 2 1 2 1 3
10	*	*	10	2 2 1 3 1 2
11	+	+	11	2 3 1 2 1 2
12	,	,	12	1 1 2 2 3 2
13	-	-	13	1 2 2 1 3 2
14	.	.	14	1 2 2 2 3 1
15	/	/	15	1 1 3 2 2 2
16	0	0	16	1 2 3 1 2 2
17	1	1	17	1 2 3 2 2 1
18	2	2	18	2 2 3 2 1 1
19	3	3	19	2 2 1 1 3 2
20	4	4	20	2 2 1 2 3 1
21	5	5	21	2 1 3 2 1 2
22	6	6	22	2 2 3 1 1 2
23	7	7	23	3 1 2 1 3 1
24	8	8	24	3 1 1 2 2 2
25	9	9	25	3 2 1 1 2 2
26	:	:	26	3 2 1 2 2 1
27	;	;	27	3 1 2 2 1 2
28	<	<	28	3 2 2 1 1 2
29	=	=	29	3 2 2 2 1 1
30	>	>	30	2 1 2 1 2 3
31	?	?	31	2 1 2 3 2 1
32	@	@	32	2 3 2 1 2 1
33	A	A	33	1 1 1 3 2 3
34	B	B	34	1 3 1 1 2 3
35	C	C	35	1 3 1 3 2 1
36	D	D	36	1 1 2 3 1 3
37	E	E	37	1 3 2 1 1 3
38	F	F	38	1 3 2 3 1 1
39	G	G	39	2 1 1 3 1 3
40	H	H	40	2 3 1 1 1 3
41	I	I	41	2 3 1 3 1 1
42	J	J	42	1 1 2 1 3 3
43	K	K	43	1 1 2 3 3 1
44	L	L	44	1 3 2 1 3 1
45	M	M	45	1 1 3 1 2 3
46	N	N	46	1 1 3 3 2 1
47	O	O	47	1 3 3 1 2 1
48	P	P	48	3 1 3 1 2 1
49	Q	Q	49	2 1 1 3 3 1
50	R	R	50	2 3 1 1 3 1
51	S	S	51	2 1 3 1 1 3
52	T	T	52	2 1 3 3 1 1
53	U	U	53	2 1 3 1 3 1
54	V	V	54	3 1 1 1 2 3
55	W	W	55	3 1 1 3 2 1
56	X	X	56	3 3 1 1 2 1
57	Y	Y	57	3 1 2 1 1 3
58	Z	Z	58	3 1 2 3 1 1
59	[	[	59	3 3 2 1 1 1
60	\	\	60	3 1 4 1 1 1
61	]	]	61	2 2 1 4 1 1
62	^	^	62	4 3 1 1 1 1
63	—	—	63	1 1 1 2 2 4
64	NUL	`	64	1 1 1 4 2 2
65	SOH	a	65	1 2 1 1 2 4
66	STX	b	66	1 2 1 4 2 1
67	ETX	c	67	1 4 1 1 2 2
68	EOT	d	68	1 4 1 2 2 1
69	ENQ	e	69	1 1 2 2 1 4
70	ACK	f	70	1 1 2 4 1 2
71	BEL	g	71	1 2 2 1 1 4
72	BS	h	72	1 2 2 4 1 1
73	HT	i	73	1 4 2 1 1 2
74	LF	j	74	1 4 2 2 1 1
75	VT	k	75	2 4 1 2 1 1
76	FF	l	76	2 2 1 1 1 4
77	CR	m	77	4 1 3 1 1 1
78	SO	n	78	2 4 1 1 1 2
79	SI	o	79	1 3 4 1 1 1
80	DLE	p	80	1 1 1 2 4 2
81	DC1	q	81	1 2 1 1 4 2
82	DC2	r	82	1 2 1 2 4 1
83	DC3	s	83	1 1 4 2 1 2
84	DC4	t	84	1 2 4 1 1 2
85	NAK	u	85	1 2 4 2 1 1
86	SYN	v	86	4 1 1 2 1 2
87	ETB	w	87	4 2 1 1 1 2
88	CAN	x	88	4 2 1 2 1 1
89	EM	y	89	2 1 2 1 4 1
90	SUB	z	90	2 1 4 1 2 1
91	ESC	{	91	4 1 2 1 2 1
92	FS	|	92	1 1 1 1 4 3
93	GS	}	93	1 1 1 3 4 1
94	RS	(tilde)	94	1 3 1 1 4 1
95	US	DEL	95	1 1 4 1 1 3
96	FNC 3	FNC 3	96	1 1 4 3 1 1
97	FNC 2	FNC 2	97	4 1 1 1 1 3
98	1S B	1S A	98	4 1 1 3 1 1
99	Code C	Code C	99	1 1 3 1 4 1
100	Code B	FNC 4	Code B	1 1 4 1 3 1
101	FNC 4	Code A	Code A	3 1 1 1 4 1
102	FNC 1	FNC 1	FNC 1	4 1 1 1 3 1
103	pad	pad	pad	2 1 1 4 1 2
104	2S B	2S A	S1 B	2 1 1 2 1 4
105	2S C	2S C	S2 B	2 1 1 2 3 2
106	3S C	3S C	S3 B	2 1 1 1 3 3

Note: Shift is denoted as 1S
Double shift is denoted as 2S
Triple shift is denoted as 3S

Table 2
Code 16K Character Encodation

B and C. The bar and space patterns are shown with their equivalent data characters listed under columns for Code Set A, B or C.

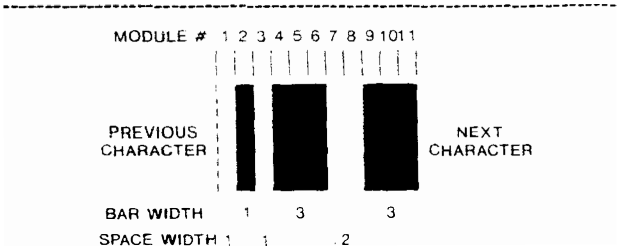

Figure 2
Encoding the Character "A"
in Code 16K

The starting symbol character defines the initial Code Set. The Code Set can be changed for subsequent symbol characters within the symbol by the characters "Code A", "Code B" or "Code C". Shift characters are available to temporarily change the Code Set for the next one, two or three symbol characters.

The same data may be represented by different Code 16K symbols, through the use of different combinations of Start, Code and Shift characters. Appendix G contains rules for generating the smallest symbol for given data.

2.2.1 Code Set A

This Code Set is used to represent the ASCII values 0 through 95, one data character per symbol character. This includes the ASCII control characters, the punctuation characters, numerics and the upper case alphabetic characters.

2.2.2 Code Set B

This Code Set is used to represent the ASCII values 32 through 127, one data character per symbol character. This includes the punctuation characters, numerics and the upper and lower case alphabetic characters.

2.2.3 Code Set C

This Code Set is used to represent numeric data, two digits per symbol character. This allows numeric data to be encoded at double density.

2.3 Special Characters

Special characters provide information to the reader and are not transmitted as data.

2.3.1 Starting Symbol Character

The starting symbol character, s, defines the starting mode, m, and the number of rows in the symbol, r. The starting mode specifies the initial Code Set and may also represent an implied leading FNC 1 character or implied leading shift character as shown in Table 3. Implied characters function as if they were actual symbol characters but do not occupy any space.

m	Initial Code Set	Implied Character
0	Code Set A	none
1	Code Set B	none
2	Code Set C	none
3	Code Set B	FNC 1
4	Code Set C	FNC 1
5	Code Set C	Shift B
6	Code Set C	Double Shift B

Table 3
Code 16K Starting Mode

The value of the starting symbol character is a packed number between 0 and 104 representing seven different starting mode set combinations and fifteen different numbers of rows:

$$s = 7(r - 2) + m$$

where r is the number of rows (2 through 16) and m is the starting mode.

Mode 5, representing Code C and implied Shift B, can be used for a single leading non-numeric and for all-numeric data with an odd number of digits, where the first numeric is represented in Code Set B. Similarly, Mode 6, Code C with implied Double Shift B, can be used for a single non-numeric followed by an odd number of digits.

Starting symbol character value 105 is

used for the extended data length symbol option (see extended data length symbol option in Appendix C).

2.3.2 *Code Characters*

The characters Code A, Code B and Code C are used to change the Code Set for the symbol characters following the code character. The new Code Set remains in effect until the end of the symbol or until the Code Set is changed again by a following code or shift character. Each of the symbol Code Sets encode the other two Code Set characters (e.g. Code A and Code C characters are defined under Code Set B). This allows a single symbol character to be used to change to any other Code Set.

2.3.3 *Shift Characters*

The shift characters are used to temporarily change the Code Set. The Code Set will automatically revert back to the previous Code Set after one, two or three symbol characters, when single, double and triple shift characters are used. The shifted symbol characters shall not be Code or shift characters.

Double Shift from Code Set C is used where there are 2 non-numeric data characters followed by an even number of numerics or 1 non-numeric data character followed by an odd number of numerics. Triple Shift from Code Set C is used where there are 3 non-numeric data characters followed by an even number of numerics or 2 non-numeric data characters followed by an odd number of numerics. In both cases, when there is an odd number of numerics, the first digit is represented in Code Set B.

Double Shift to Code Set C is used to encode 4 numerics. Triple Shift to Code Set C is used to encode 6 numerics. Numeric fields of length 5 and 7 should have the first digit encoded before the shift.

Appendix G contains a complete set of rules for the use of these characters.

2.3.4 *Function Characters*

Function characters do not change the Code Set but perform other non-data functions.

2.3.4.1 FNC 1 — Alternate Symbol Type Identifier

The use of the FNC 1 character immediately following the starting symbol character or implied by the Mode is reserved for use by the Uniform Code Council and International Article Numbering Association. This use of FNC 1 will cause the reader to transmit a symbology identifier prefix of]K1 if the symbology prefix is enabled in the reader. (See section 2.8.2 for more information on symbology identifiers.) Readers should allow Code 16K with FNC 1 as described above to be enabled separately from normal Code 16K symbols.

2.3.4.2 FNC 2 — Message Append

When the FNC 2 character is the second symbol character (immediately following the starting symbol character), the reader should temporarily store the remaining data in the symbol and append it as a prefix to the next data read from a Code 16K symbol. If multiple append symbols are read consecutively, their data will be combined in the order scanned with the last non-append mode symbol.

When the FNC 2 character is the third symbol character, the data following the FNC 2 is to be concatenated with other symbols in a prescribed order. In this case, the value of the second symbol character will be used to define the order of concatenation and the total number of symbols to be concatenated:

value/10 = order of concatenation,
modulo 10(value) = total number of symbols.

For example, if the value of the second symbol character is 37, then this symbol is the third symbol of seven to be concatenated.

If the reader decodes a Code 16K symbol without the Concatenate Mode, or a non-Code 16K symbol, it should discard the previously acquired data for concatenation.

The use of the FNC 2 character in any other position is reserved.

2.3.4.3 FNC 3 — Initialize

This instructs the reader to interpret the data contained in this symbol for reader initialization or programming. The FNC 3 may appear anywhere within the symbol following the starting symbol character.

2.3.4.4 FNC 4 — User Defined

This character is available for application specific definition.

2.3.5 Pad Character

This character has three functions. When it appears at the end of the symbol characters, just before the check characters, it represents no data. This is used to fill the last row or rows whenever the number of data characters do not require the number of symbol characters in the symbol.

Whenever this character is inserted within the symbol characters encoding data, it functions as a data separator. This allows a single Code 16K symbol to contain several different variable length data fields. The reader should treat the data encoded before and after this character as if they came from separate symbols (i.e., each field should be stored or transmitted with its own prefix and suffix characters).

If the pad character is in the first data position, it will cause the reader to transmit a symbology identifier prefix option of]K4 (if the symbology prefix is enabled in the reader). This can be used to designate another industry specific Code 16K symbol similar to FNC 1.

2.4 Start and Stop Characters

The start character is a bar-space-bar-space pattern 7X wide. The patterns are edge-to-edge decodable and even parity (the sum of the module widths in the bars is always even). Eight patterns are defined as shown in Table 4.

The stop character is a space-bar-space-bar pattern 7X wide. The patterns are edge-to-edge decodable and odd parity. Eight patterns are defined. The pattern is the same as the start character's, but the bars are spaces and the spaces are bars as shown in Table 5.

Each row in the symbol is assigned a unique pair of start and stop characters which identifies the row as shown in Table 6.

The rows are numbered starting with row one at the top of the symbol.

2.5 Guard Bar

A 1X Guard Bar is used following the start pattern. The start and stop patterns and the guard bar are shown in Figure 3.

Value	**b**	**s**	**b**	**s**
0	3	2	1	1
1	2	2	2	1
2	2	1	2	2
3	1	4	1	1
4	1	1	3	2
5	1	2	3	1
6	1	1	1	4
7	3	1	1	2

Table 4
Start Patterns

Value	**s**	**b**	**s**	**b**
0	3	2	1	1
1	2	2	2	1
2	2	1	2	2
3	1	4	1	1
4	1	1	3	2
5	1	2	3	1
6	1	1	1	4
7	3	1	1	2

Table 5
Stop Patterns

2.6 Check Characters

The Check Characters are used to detect and prevent symbol decode errors. The next to the last symbol character is the first Check Character, C1, and the last symbol character is the second Check Character, C2. The check characters are the modulo 107 weighted sum of the preceding symbol characters in the symbol. The weights for the C1 calculation start at two for the starting symbol character, S, increase by one for each successive symbol character and end with the symbol character immediately preceding C1:

C1 = modulo 107 (sum of ((i + 1) * Char(i))) summed from i = 1 to number of symbol characters - 2.

Row	Start	Stop
1	0	0
2	1	1
3	2	2
4	3	3
5	4	4
6	5	5
7	6	6
8	7	7
9	0	4
10	1	5
11	2	6
12	3	7
13	4	0
14	5	1
15	6	2
16	7	3

Table 6
Start and Stop Values
Defining Row Number

The weights for the C2 calculation start at one for the starting symbol character, S, increase by one for each successive symbol character and end with the symbol character immediately preceding C2 (the C1 character):

C2 = modulo 107 (sum of (i * Char(i))) summed from i = 1 to number of symbol characters - 1.

2.7 Symbol Structure

Figure 3 shows the format of a 16-row Code 16K symbol.

2.8 Transmitted Data

2.8.1 Data Characters

All encoded data characters are included in the data transmission. The starting symbol character, code characters, shift characters, function characters and the two check characters are not transmitted.

2.8.2 Symbology Identifier Prefix

A symbology identifier prefix may be transmitted by the reader to identify the symbology read and any options. For Code 16K, the symbology identifiers are:

]K0	No special characters in the first or second data character positions
]K1	FNC 1 in the first data character position
]K2	FNC 1 in the second data character position
]K4	Pad Character in the first data character position

A complete set of symbology identifiers for all symbologies is available from AIM.

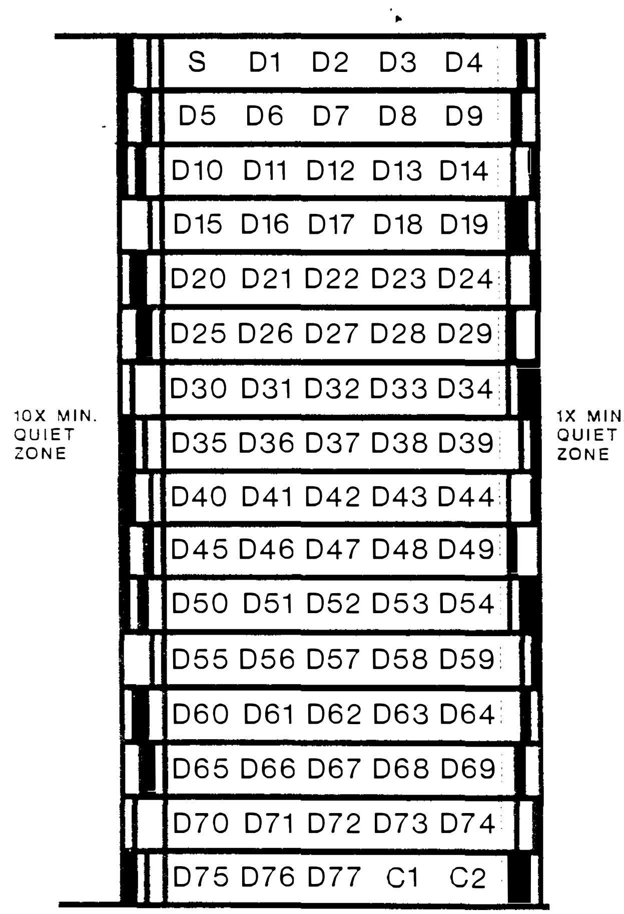

Figure 3
Code 16K Symbol Structure

3.0 DIMENSIONS AND TOLERANCES

3.1 Measurement Conditions

Implicit in the measurement of code element width is the measurement which locates the boundary between the light and dark elements of the code. In order to allow for measurements to be made in the presence of edge roughness, spots and voids, the boundary is defined as the position of the center of a circular sample aperture no larger than 0.8X when the apparent reflectance of the sample viewed through the aperture is exactly half way between the maximum and minimum reflectance values obtained by that aperture on the adjacent bar and space. X is the nominal width of a narrow element.

3.2 X Dimension

Code 16K may be printed at various densities to accommodate a variety of printing and scanning processes. The significant dimensional parameter is X, the nominal width of a module. One module is the nominal width of the narrowest bars and spaces.

The minimum standard X dimension used is 0.0075 inches (0.191 mm). This limit reflects the current technology for a range of standard scanning devices. (See Appendix F for non-standard X dimensions.)

3.3 Minimum Bar Height

A minimum bar height of 8X is recommended for ease of scanning with linear scanners.

3.4 Quiet Zones

The quiet zones are areas that are free and clear of all printing preceding the start pattern and following the stop pattern.

The minimum quiet zone is ten modules adjacent to the start pattern and one module adjacent to the stop pattern. Where space permits, a ten module quiet zone adjacent to the stop pattern is recommended.

3.5 Dimensional Tolerances

The various processes used to prepare bar code symbols have a limited capacity to produce the bars and spaces with widths which precisely match the ideal symbol. Bar code reading systems are designed to read imperfect symbols to the extent that practical algorithms permit. Appendix B describes the reference decode algorithm used in the derivation of the error tolerances given below.

Three sets of measurements are required to determine the tolerances for every character. These measurements apply to all symbol characters and the start and stop characters. The bar measurement applies to the guard bar.

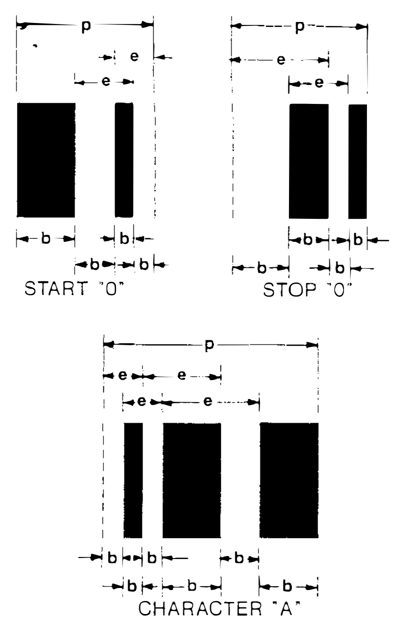

Figure 4
Character Measurements

The symbol character to symbol character tolerance, t_p, is the maximum amount the total width of the character, p, can vary from its nominal dimension. See Figure 4.

The bar or space tolerance, t_b, is the maximum amount any of the bar widths and space widths may vary from its nominal dimension.

The edge to edge tolerance, t_e, is the maximum amount any of the indicated dimensions, e, may vary from their nominal dimensions. These dimensions are measured from the leading edge of a bar to the leading edge of the following bar, or the trailing edge of a bar to the trailing edge of the following bar. See Figure 4.

The value of tolerances t_b, t_e, and t_p are defined as:

$t_b = \pm 0.40X - 0.0005$ inches (0.013 mm)
$t_e = \pm 0.20X$
$t_p = \pm 0.20X$
where:
X is the nominal minimum dimension.

Table 7 lists the calculated tolerances for various X dimensions.

These tolerances are represented graphically in Figure 5.

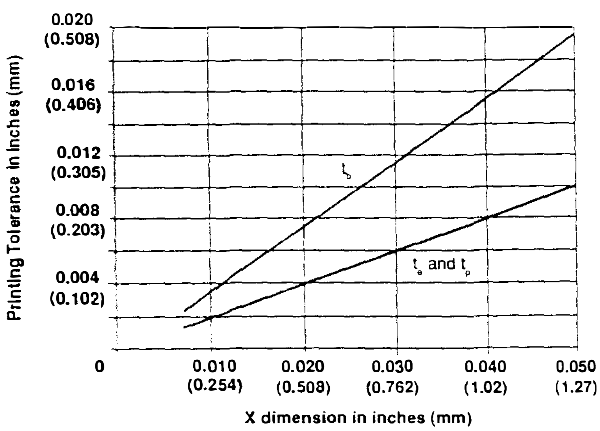

Figure 5
Code 16K Tolerance Values
Graph

3.6 Symbol Size

3.6.1 Symbol Width

The overall width of a symbol is equal to 81X, including quiet zones. This is the sum of the 10X minimum left quiet zone, the 70X bars and spaces and the 1X minimum right quiet zone.

3.6.2 Symbol Height

The overall "height" of a symbol is a function of X, the bar height, and the number of rows, as follows:

$$H = ((h+g)r+g)X$$

where:

H = height of the symbol
h = height of the individual bars (in multiples of X)
r = number of rows (2 to 16)
g = height of separator bar (in multiples of X)

X	t_b	t_e	t_p
7.5	2.5	1.5	1.5
8.0	2.7	1.6	1.6
9.0	3.1	1.8	1.8
10.0	3.5	2.0	2.0
12.0	4.3	2.4	2.4
14.0	5.1	2.8	2.8
17.0	6.3	3.4	3.4
20.0	7.5	4.0	4.0
30.0	11.5	6.0	6.0
40.0	15.5	8.0	8.0
50.0	19.5	10.0	10.0

X is nominal module width
t_b is bar or space tolerance
t_e is edge to edge tolerance
t_p is symbol character to symbol character tolerance
All measurements are in 0.001 inch

Table 7
Tolerance Values

4.0 Optical Specification

4.1 Introduction and Summary

The optical characteristics of the printed bar code symbols can vary substantially because of the varied processes which may be used to produce them. It is necessary that certain optical properties be maintained within acceptable limits if the reading process is to be reliable. In particular, this specification describes the reflectance characteristics of the bar and space elements within the symbol and the spectral band to be used by the reflectance measurement equipment.

The reflectance specifications have been designed so that a sufficiently discernible difference in reflectance exists between spaces and bars. The difference must be at least 37.5 percentage points for symbols with an X dimension of less than 0.040 inches (1.02 mm) and at least 20 percentage points for symbols with an X dimension of 0.040 inches (1.02 mm) or larger. Bar reflectance must always be less than 30 percent and space reflectance more than 25 percent.

Finally, this specification limits the amount of noise, that is, the reflectance variation, which can be tolerated within a bar or space and across the entire symbol. Noise can be caused by such printing defects as spots and voids, non-uniformity in the substrate material, or the show-through of patterns under a substrate which is not adequately opaque. Reflectance variation within the bars or spaces must be limited to be no greater than one-quarter the minimum reflectance difference between bars and spaces. In other words, the noise within one symbol element cannot exceed 25 percent of the minimum signal amplitude obtained between bars and spaces. Across an entire symbol, the reflectance of either the set of bars or the set of spaces can not vary any more than one-half the minimum reflectance difference between bars and spaces. The combined noise from all optical sources must not cause these limits to be exceeded.

A more detailed presentation of the optical specifications is given in the sections which follow. Measurements have been defined in a manner which in many respects parallels the operation of most bar code reading systems.

4.2 Measurement Conditions

4.2.1 Spectral Band

All AIM USS symbols must satisfy the minimum reflectance specification cited below for the spectral band centered at 633 nanometres in the visible spectrum. Measurements shall be made with a system having its peak response at 633 nanometres $\pm$ 5 percent and having a half-power band width no greater than 120 nanometres (in which there are no secondary peaks). Among possible source-filter-photodetector combinations which can be used are those employing a He-Ne laser, appropriate red LED's or alternatively the CIE Source A illuminant (incandescent source) along with an S-4 response photodetector and a Wratten 26 red filter.

Appendix F includes a discussion of systems which are designed to operate in spectral bands other than the 633 nanometer band.

4.2.2 Diffuse Reflectance Measurements of Bars and Spaces

The diffuse reflectance of a surface is defined to be the ratio of the diffusely reflected radiation from the surface to that reflected from a specially prepared Magnesium Oxide or Barium Sulfate standard that is measured under the same illuminating and viewing conditions. Standard viewing conditions require the viewing and illuminating axes to be separated by 45 degrees with one of the axes positioned normal to the sample surface. In order to reject specular reflections, the aperture of the viewing and illuminating system should subtend an angle no greater than 15 degrees measured from the sample surface.

Either the light source or the receiver must restrict the sample field to an area equal to a circle of diameter 0.8X, where X is the width of a narrow element of the bar code, or as specified in an application standard. The other optical path must have a field of view on the sample large enough to include a circle of diameter 8X or more, centered on the 0.8X diameter circle defined above. The two alternatives represent either flood illumination with sample area viewing defined as the receiver or illuminant sampling of the area as with a focused light source and wide area viewing.

4.3 Essential Bar Code Measurements

4.3.1 Measurement Conditions

The reflectance specifications given below are based upon signal-to-noise requirements for the reliable decoding of a symbol by a bar code reader. The signal is the reflectance difference between a bar and a space. Noise is any variation in reflectance caused by gradations in the ink or substrate material. Spots and voids in the symbol and the show-through of a pattern underlying a label with low opacity can also contribute to noise in bar and space reflectance values. It is essential, therefore, that a symbol be sampled adequately and that conditions under which an underlying dark surface or pattern may affect the symbol quality be included in the measurement process. The net effect of all noise contributing factors must not cause the symbol reflectance measurements to fall outside the stated specifications.

4.3.2 Reflectance Measurements

Figure 6 depicts the bar code reflectance measurement process and in graphical form shows the key measurement parameters required to describe the quality of the bar code symbol. Figure 6a indicates the position of the sample aperture on a bar code image in which reflectance measurements are made. Note that all sample reflectance measurements are made with the sampling aperture confined within the area of a space or bar. No reflectance measurements are made with the aperture positioned across the edge of a bar and space as defined in Section 3.1 above. A plot of the reflectance measurements is shown in Figure 6b along with annotations describing the essential bar code reflectance parameters. On the left are indicated the maximum space reflectance R_S (MAX), the minimum space reflectance R_S (MIN), and the maximum bar reflectance R_B (MIN), obtained over all samples. On the right are indicated the ranges of reflectance ΔR_E obtained from a typical space and a typical bar element.

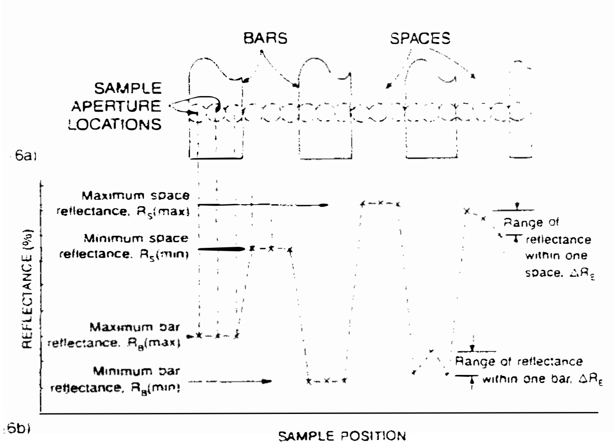

Figure 6
Bar Code Reflectance Measurements

4.4 Reflectance Specifications

The reflectance characteristics of AIM USS symbols must comply with the following specification:

4.4.1 Maximum Bar Reflectance (R_B)

R_B(MAX) < 30 percent

4.4.2 Minimum Space Reflectance (R_S)

R_S(MIN) > 25 percent

4.4.3 Minimum Bar-Space Reflectance Difference, MRD

The difference in reflectivity between the lightest bar and the darkest space is called MRD (Minimum Reflectance Difference). In other words,

MRD = R_S(MIN) - R_B(MAX).

The minimum value of MRD is:

MRD $\geq$ 37.5 percent for X < 0.040 inches (1.02 mm)
MRD $\geq$ 20.0 percent for X $\geq$ 0.040 inches (1.02 mm)

The special provisions for symbols with X $\geq$ 0.040 inches (1.02 mm) have been made in order to accommodate the printing of lower density labels on darker backgrounds.

4.4.4 Element Uniformity

4.4.4.1 Maximum variation in reflectance of a single element, ΔR_E (MAX)

The maximum permissible variation in the reflectance measurements made across one bar or space element cannot exceed one quarter of the MRD defined in 4.4.3;

ΔR_E(MAX) across one element $\leq$ 0.25 MRD

4.4.4.2 Maximum variation in reflectance of spaces across entire symbol, ΔR_S(MAX)

The maximum permissible variation in the reflectance across all spaces is one-half of the minimum bar-space reflectance difference as defined in 4.4.3;

ΔR_S(MAX) = R_S(MAX) - R_S(MIN) $\leq$ 0.5 MRD

4.4.4.3 Maximum variation in the reflectance of bars across entire symbol, $\Delta R_B(MAX)$

The maximum permissible variation in the reflectance across all bars is one-half the actual measured value of the minimum bar-space reflectance difference as defined in 4.4.3 above;

$\Delta R_B(MAX) = R_B(MAX) - R_B(MIN) \leq 0.5$ MRD

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Appendix A

Glossary of Terms

AIM — Automatic Identification Manufacturers, Inc. The publishers of this document.

Alignment — In an automatic identification system, the relative position and orientation of a scanner to the symbol.

Alphanumeric — The character set which contains letters, numbers and may contain other characters such as punctuation marks or control characters.

ANSI — The American National Standards Institute--nee United States of America Standards Institute (USASI)--is a non-governmental organization responsible for the development of voluntary industry standards.

Aperture — The opening in an optical system (scanner) implemented by a physical baffle that establishes the field of view.

ASCII — The character set and code described in American National Standard Code for Information Interchange, **ANSI** X3.4-1977. Each ASCII character is encoded with 7-bits (8 bits including parity check). The ASCII character set is used for information interchange between data processing systems, communication systems and associated equipment. The ASCII set consists of both control and printing characters.

Aspect Ratio — In a bar code symbol, the ratio of bar height to symbol length.

Autodiscrimination — The ability of bar code reading equipment to recognize and correctly decode more that one symbology.

Background — The spaces, quiet zones and area surrounding a printed symbol.

Bar — The darker element of a printed bar code symbol.

Bar Code — An automatic identification technology which encodes information into an array of varying width parallel rectangular bars and spaces.

Bar Code Character — See "Character, Symbol"

Bar Code Density — The number of data characters which can be represented in a linear unit of measure. Bar code density is often expressed in characters per inch (CPI).

Bar Code Label — A label which carries a bar code symbol and is suitable to be affixed to an article.

Bar Code Reader — A device used to read a bar code symbol.

Bar Code Symbol — See "Symbol".

Bar Height — See "Bar Length".

Bar Length — The bar dimension perpendicular to the bar width. Also called height.

Bar Width — The thickness of a bar measured from the edge closest to the symbol start character to the trailing edge of the same bar.

Bar Width Reduction — Reduction of the nominal bar width dimension of film masters or printing plates to compensate for systematic errors in some printing processes.

Bidirectional — A bar code symbol capable of being read successfully independent of scanning direction.

Bidirectional Read — See "Bidirectional".

Binary — The number system that uses only 1's and 0's.

Bit — An abbreviation for "binary digit". A single element (0 or 1) in a binary number.

Centerline — The vertical axis around which character elements are located for letters, numerals, or symbols.

Character

1. Code Character — in Code 49, one of two data characters which make up a symbol character. In Code 128 and Code 16K, characters used to change Code Sets.

2. Data Character — a letter, digit or other symbol which is a member of the ASCII character set.

3. Human Readable Character — the letter(s), digit(s) or other symbol associated with a specific symbol character(s) and printed along with the bar code

symbol.

4. Symbol Character — a unique bar and/or space pattern which is defined for that symbology. There is not necessarily a one-to-one or unique correlation between symbol characters and data characters. Symbol characters may have a unique associated symbol value.

Character Self-Checking — the feature which allows a bar code reader to determine if a scanned group of elements is a valid symbol character. If a symbology is described as being character self-checking, a single printing defect (edge error) in any symbol character does not produce another valid character.

Character Alignment — The vertical or horizontal position of characters with respect to a given set of reference lines.

Character Set — Those characters available for encodation in a particular automatic identification technology.

Check Character — A character included within a message whose value is used for the purpose of performing a mathematical check to ensure the accuracy of that message.

Check Digit — See "Check Character".

Clear Area — See "Quiet Zone".

Codabar — (2 of 7 Code, Code 27). A numbers only bar code consisting of seven modules, two of which are wide. See AIM USS-Codabar for specifications.

Code — See "Bar Code".

Code 39 — (3 of 9 Code). A full alphanumeric bar code consisting of nine modules, three of which are wide. See AIM USS-39 for specifications.

Code 93 — A full alphanumeric bar code capable of encoding all 128 ASCII characters. See AIM USS-93 for specifications.

Code 128 — A full alphanumeric bar code capable of encoding all 128 ASCII characters. See AIM USS-128 for specifications.

Code 16K — A full alphanumeric, multi-row bar code capable of encoding all 128 ASCII characters. See AIM USS-16K for specifications.

Code 49 — A full alphanumeric, multi-row bar code capable of encoding all 128 ASCII characters. See AIM USS-49 for specifications.

Code Set — The specific assignment of data characters to symbol characters.

Code Reader — See "Bar Code Reader".

Continuous Code — A bar code symbology where all spaces within the symbol are parts of characters, e.g. USS-I 2/5. There is no intercharacter gap in a continuous code.

CPI — Characters per inch (see "Bar Code Density").

Data Character —See "Character".

Decoder — As part of a bar code reading system, the electronic package which receives the signals from the scanner, performs the algorithm to interpret the signals into meaningful data and provides the interface to other devices.

Density — See "Bar Code Density".

Depth of Field — The distance between the maximum and minimum plane in which a code reader is capable of reading symbols.

Diffuse Reflection — The component of reflected light which emanates in all directions from the reflecting surface.

Discrete Code — A bar code symbology where the spaces between characters (intercharacter gap) are not part of the code, e.g. USS-39.

Dot Matrix — A system of printing where individual dots are printed in matrix (5x7, 7x9, etc.) forming bars, alphanumeric characters and simple graphics. See AIM document T-11, "Matrix Impact Printing", for specifications.

Dot Size — The size of the printed dot laid down on a substrate in a matrix or line to form characters.

Element — In a bar code symbol, a single bar or space.

Element Width — the thickness of a bar or space measured from the edge closest to the symbol start character to the trailing edge of the same bar or space.

Film Master — A photographic film representation of a specific bar code or OCR symbol from which a printing plate is produced.

First Read Rate — See "Read Rate".

Font — A specific size and style of type.

Guard Bars — Bars which provide reference points for scanning but are not part of the symbol characters. For example, the bars which are at both ends and center of a UPC and EAN symbol.

He-Ne — Common name for helium neon laser.

Horizontal Bar Code — A bar code or symbol presented in such a manner that its overall length dimension is parallel to the horizon. The bars are presented in an array which look like a picket fence.

Human Readable Character — See "Character."

Intercharacter Gap — The space between two adjacent bar code characters in a discrete code. For example, the space between characters in USS-39.

Interleaved Bar Code — A bar code in which characters are paired together using bars to represent the first character and spaces to represent the second, e.g. USS-I 2/5 (see also "Continuous Code").

Interleaved Two of Five Code — (I 2/5) — A number only bar code symbology consisting of five bars, two of which are wide. In this code both the bars and spaces carry information. See AIM X-5-1 USS I 2/5 for specifications.

Ladder Code — See "Vertical Bar Code".

LED — Light emitting diode. A semiconductor that produces light at a wavelength determined by its chemical composition. A light source often used in bar code readers.

LOGMARS — Logistics of marking and reading symbols. A Department of Defense program to place a Code 39 symbol on all federal items. For specifications see Mil-Std 1189.

Misread — A condition which occurs when the data output of a reader does not agree with the data encoded in the bar code symbol.

Module — The narrowest nominal width unit of measure in a bar code.

Modulo Check Digit or Character — See "Check Character".

Moving Beam Scanner — A scanning device where scanning motion is achieved by mechanically moving the light beam through the bars.

Multi-Row Symbology — Symbologies where a long symbol is broken into sections and "stacked" one upon another similar to sentences in a paragraph. Extremely compact codes. Code 16K and Code 49 are examples of multi-row symbologies.

Nanometre — A unit of measure (10^{-9} metre) used to define the wavelength of light. Many standards require scanning in the 633-900 nanometre range.

Nominal — The exact (or ideal) intended value for a specified parameter. Tolerances are specified as positive and negative deviations from this value.

Non-read — In a bar code system, the absence of data at the scanner output after an attempted scan due to no code, defective code, scanner failure or operator error.

Numeric — A character set that includes only numbers.

Opacity — The optical property of a substrate material that minimizes show-through from the back side or the next sheet. The ratio of the reflectance with a black backing to the reflectance with a white backing. Ink opacity is the property of an ink that prevents the substrate from showing through.

Orientation — The alignment of a bar code symbol with respect to horizontal. Two possible orientations are horizontal with vertical bars and spaces (picket fence) and vertical with horizontal bars and spaces (ladder).

Overhead — In a bar code system, the fixed number of characters required for start, stop and checking in a given symbol. For example, a symbol requiring a start/stop and two check characters contains four characters of overhead. Thus, to encode three characters, seven characters are required to be printed.

Picket Fence Code — See "Horizontal Bar Code".

Print Quality — The measure of compliance of a bar code symbol to the requirements of dimensional tolerance, edge roughness, spots, voids, reflectance, quiet zone, and encodation.

Quiet Zone — A clear space, containing no machine readable marks, which precedes the start character of a bar code symbol and follows the stop characters. Sometimes called the "Clear Area".

Read Rate — The ratio of the number of successful reads on the first attempt to scan to the total number of attempts.

Reflectance — The ratio of the amount of light of a specified wavelength or series of wavelengths reflected from a test surface to the amount of light reflected from a barium oxide or magnesium oxide standard under similar illumination conditions.

Resolution — In a bar code system, the narrowest element dimension which can be distinguished by a particular reading device or printed with a particular device or method.

Scanner — An electronic device to read bar codes that electro-optically converts bars and spaces into electrical signals.

Self-checking — A bar code or symbol using a checking algorithm which can be independently applied to each character or symbol to guard against undetected errors.

Show-through — The generally undesirable property of a substrate that permits underlying markings to be seen and may adversely affect read rate.

Skew — Rotation of a bar code symbol about an axis parallel to the symbol's length.

Space — The lighter element of a bar code usually formed by the background between bars.

Space Width — The thickness of a space measured from the edge closest to the symbol start character to the trailing edge of the same space.

Spectral Response — The variation in sensitivity of a reading device to light of different wavelengths.

Specular Reflection — The mirror-like reflection of light from a surface.

Spot — The undesirable presence of ink or dirt in a space.

Spot Size — The diameter of the beam of light used to scan a bar code symbol — ideally the beam width should be the same as the width of the narrow bar.

Stacked Codes — See "Multi-row Symbology"

Standard — A set of rules, specifications, instructions and directions to use a bar code or other automatic identification system to your profit. Usually issued by an organization, e.g. Logmars, HIBCC, UPC, etc.

Start-Stop Character or Pattern — A special bar code character that provides the scanner with start and stop reading instructions as well as scanning direction indicator. The start character is normally at the left-hand end of a horizontally oriented symbol. The stop character is normally at the right-hand end of a horizontally oriented symbol.

Substitution Error — A mis-encodation, mis-read, or human key entry error where a character that was to be entered is substituted with erroneous information. Example: Correct information--1,2,3,4, substitution--1,2,3,5.

Substrate — The surface on which a bar code symbol is printed.

Symbol — A combination of bar code characters including start/stop characters, quiet zones, data characters, and check characters required by a particular symbology, which form a complete, scannable entity.

Symbol Character — See "Character".

Symbol Density — See "Bar Code Density".

Symbol Length — The distance between the outside edges of the quiet zones.

Symbology Identifier — An optional three character code which may prefix transmitted data from a bar code reader indicating the symbology read and any options enabled in the reader or special features of a symbology encountered (e.g., presence of FNC 1).

Tilt — Rotation of a bar code symbol about an axis perpendicular to the substrate.

USS — Uniform Symbology Specification. The current series of symbology specifications published by AIM which currently include USS-I 2/5, USS-39, USS-93, USS-Codabar, USS-128, USS-49 and USS-16K.

Verifier — A device that makes measurements of the bars, spaces, quiet zones and optical characteristics of a symbol to determine if the symbol meets the requirements of a specification or standard.

Vertical Bar Code — A code pattern presented in such orientation that the axis of the symbol from start to stop is perpendicular to the horizon. The individual bars are in an array appearing as rungs of a ladder.

Void — The undesirable absence of ink in a bar.

"X" Dimension — The nominal dimension of the narrow bars and spaces in a bar code symbol.

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Appendix B

Reference Decode Algorithm for USS-16K

The allowable print tolerances for Code 16K (see Section 3.5) are derived from the characteristics of a reference decode algorithms for the symbol characters and the start and stop characters. In these algorithms the symbol is decoded using "edge to similar edge" measurements.

B.1 Start and Stop Characters

The algorithm to decode the start and stop characters contains the following steps:

1. Calculate the three width measurements p, t1 and t2. See Figure 7, Start and Stop Characters.

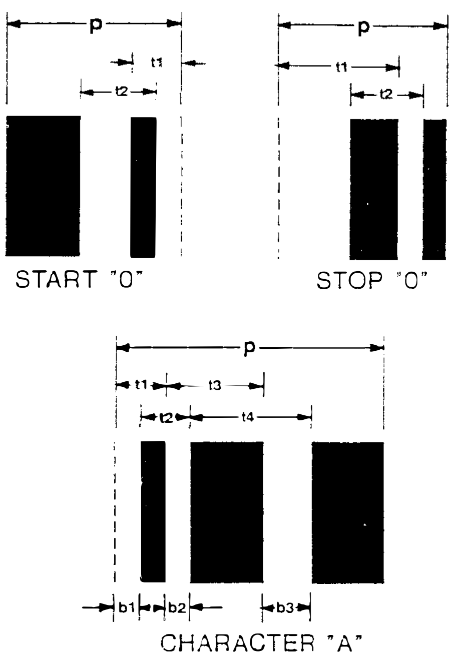

Figure 7
Decode Measurements

2. Convert measurements t1 and t2 to normalized values T1 and T2 which will represent the integer module width of these measurements. The following method is used for the i-th value:

   If $1.5p/7 \leq ti < 2.5p/7$, the Ti is 2;
   If $2.5p/7 \leq ti < 3.5p/7$, the Ti is 3;
   If $3.5p/7 \leq ti < 4.5p/7$, the Ti is 4;
   If $4.5p/7 \leq ti < 5.5p/7$, the Ti is 5;
   otherwise the character is in error.

3. Look up the character in a decode table using the two values T1 and T2 as the key. The table should indicate the character value 0-7 and whether it is a start or stop character or whether it is in error. The first start or stop character decoded will be used to define the direction of the scan. The direction will be used to determine the location of the symbol characters in the row.

   If the character is in error or if there is not a valid start and stop pair, then the row scan is invalid.

B.2 Symbol Characters

Symbol characters are decoded using edge-to-edge measurements. Character parity is checked by an additional comparison to a character self checking parity table. The algorithm contains the following steps to decode each of the five symbol characters in the scan row.

1. Calculate eight width measurements p, t1, t2, t3, t4, b1, b2, and b3. See Figure 7, Symbol Character.

2. Convert measurements t1, t2, t3 and t4 to normalized values T1, T2, T3 and T4 which will represent the integer module width of these measurements. The following method is used for the i-th. value.

   If $1.5p/11 \leq ti < 2.5p/11$, then Ti is 2;
   If $2.5p/11 \leq ti < 3.5p/11$, then Ti is 3;
   If $3.5p/11 \leq ti < 4.5p/11$, then Ti is 4;
   If $4.5p/11 \leq ti < 5.5p/11$, then Ti is 5;
   If $5.5p/11 \leq ti < 6.5p/11$, then Ti is 6;
   If $6.5p/11 \leq ti < 7.5p/11$, then Ti is 7;
   Otherwise, the character is in error.

3. Look up the character in a decode table using the four values, T1, T2, T3, and T4 as the key.

4. Retrieve the value V, which is equal to the sum of the modules in the spaces as defined for that character.

5. Verify that:

$(V - 1.75)p/11 \leq (b1 + b2 + b3) \leq (V+1.75)p/11$

Otherwise, the character is in error. This calculation indirectly uses character parity to detect all decode errors caused by single non-systematic one-module edge errors.

Use these five steps to decode each character. If any of the symbol characters are in error, the row scan is invalid.

B.3 Symbol Decode

When a row is decoded without error, store it as one of the 16 possible rows according to the start and stop values. If a duplicate row is decoded with different data, reject all previous row decodes for the symbol.

When row number one is decoded, determine the number of rows from the starting symbol character. When all the rows in the symbol are decoded, calculate and verify the two check characters.

If a check character is in error, reject all the row decodes. Otherwise convert the symbol character values into data characters according to the mode and the code and shift characters.

B.4 Additional Checks

Perform checks for quiet zones, character to character widths, the 1X guard bar and absolute timing to reduce the occurrence of erroneous row decodes. Perform such other checks as are deemed prudent and appropriate considering the specific reading device and intended application environment.

Appendix C

Optional Characteristics of USS-16K

C.1 Extended Data Length Option

Each standard Code 16K symbol must be scanned separately from other Code 16K symbols. They cannot be stacked vertically or placed too close together horizontally because the scanner might read a row from the adjacent symbol before all of the current symbol's rows are decoded. However, the extended data length option specifically allows up to 107 16-row symbols to be stacked and concatenated.

Each of the 16-row symbol blocks in an extended data length symbol stack is identified by a starting symbol character, s, with a value of 105. Every extended data length symbol starts in Code Set B and has 16 rows.

The second and third symbol characters, the two symbol characters immediately following the starting symbol character, in each of the 16-row symbol blocks in the stack define its order within the stack and the total number of blocks in the stack.

The second symbol character defines the order within the stack or symbol number. Its value is the symbol number minus one.

The third symbol character defines the total number of 16-row symbol blocks in the stack. Its value is the total number minus one. For example, the first 16-row symbol block in a stack of 20 symbols would have values of zero (0) and 19 for the second and third symbol characters.

Row	Start Value	Stop Value
1	0	0
2	1	1
3	2	2
4	3	3
5	4	4
6	5	5
7	6	6
8	7	7
9	0	4
10	1	5
11	2	6
12	3	7
13	4	0
14	5	1
15	6	2
16	7	3

Table C-1
Odd Block Row Patterns

The fourth symbol character is the first to encode data in the symbol.

In an extended data length symbol, each row in the symbol is assigned a unique pair of start and stop characters which identifies the row and the odd or even symbol block.

The first and succeeding odd numbered symbol blocks have row patterns as shown in Table C-1.

The second and succeeding even numbered symbol blocks have row patterns as shown in Table C-2.

Row	Start Value	Stop Value
1	0	2
2	1	3
3	2	4
4	3	5
5	4	6
6	5	7
7	6	0
8	7	1
9	0	6
10	1	7
11	2	0
12	3	1
13	4	2
14	5	3
15	6	4
16	7	5

Table C-2
Even Block Row Patterns

The use of the alternating row pattern sets allow the scanner to disregard the rows read from adjacent 16-row symbols. It is assumed that the extended stack will be decoded in ascending or descending order, with each 16-row symbol being decoded before proceeding to the next symbol in the stack.

Many readers will not have buffer memory large enough to store the data for the maximum length extended symbol (8,025 characters or 15,836 digits). The storage capability of the readers must be considered when this option is used.

Appendix D

Human Readable Interpretation

A human readable representation of the data characters in the symbol (equivalent to the transmitted characters) may accompany the symbol. It should not interfere with the symbol itself nor the quiet zones.

12345678901234

Appendix E

Autodiscrimination Compatibility

Some readers may be programmed to automatically discriminate among symbols encoded in other symbologies. Code 16K is compatible for use in an autodiscrimination environment with any of the following symbologies:

- Code 39
- Interleaved 2-of-5
- Codabar
- Code 93
- Code 128
- Code 49
- UPC
- EAN

It is advisable to limit the reader's valid set of symbologies and symbol lengths to those needed by a given application in order to maximize reading security.

Appendix F

Systems Considerations

It is important that the various components (printers, labels, readers) 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.

When both readers and printers are specified by a single user or by cooperative agreement (closed system), certain specified values such as X dimensions and spectral band can be allowed to deviate from standard tolerances. But the characteristics of the printer, symbol, and reader must be matched to achieve desired performance. Deviations should only be considered where standard specifications do not yield acceptable results, and where system component vendors and integrators take appropriate care to achieve required system matching.

X Dimension

In closed systems, the X dimension may be less than 0.0075 inches (0.1910 mm). The user must exercise care in these systems to assure a match between the reader resolution and printed symbol X dimension.

In these applications, where the X dimension is less than 0.0075 inches (0.191 mm), the tolerance t_b is defined as:

$$t_b = \pm 0.33X$$

Spectral Band

In closed systems, a reference spectral band other than 633 nanometres may be specified. In such systems, it is important to assure that the spectral response characteristics of the reading equipment is matched to the spectral reflectance characteristics of the printed symbols.

Other Considerations

Compliance with specifications is one key to assuring overall system success, but other considerations come into play which can influence performance as well. The following guidelines suggest some factors to keep in mind when specifying or implementing bar code systems:

1. Choose a symbology and print density which yield tolerance values which can be achieved by the printing technology to be used.
2. Choose a reader with resolution suitable for the symbol density and quality produced by the printing technology.
3. Be certain that the printed symbol's optical properties are within specification for the spectral band employed by the reader.
4. Be sure to verify symbol specification compliance in the final label or package configuration. Overlays, show-through, and curved or irregular surfaces can all affect symbol readability.
5. Bar height should generally be set at the highest value that is practical, given label, package, and printing technology constraints.
6. To the extent possible, reading equipment should be configured to accept only those symbologies and symbol lengths which are required by the system.

The effects of specular (mirror-like) reflections from shiny symbol surfaces must be considered. Standard reading systems are designed to detect variations in diffuse reflection between bars and spaces. At some reading angles, the specular component of the reflected light can greatly exceed the desired diffuse component, reducing read performances. Matte, non-glossy finishes minimize this effect.

In cases where specular reflection effects are used to achieve the desired contrasts (as in some forms of printing or etching directly onto metal), extreme care must be exercise to assure that the optical properties are within specifications over the entire range of read angles and distances required by the particular application.

Appendix G

Printing Code 16K

Use of Mode and Code and Shift Characters

The same data may be represented by different Code 16K symbols through the use of different combinations of mode and code and shift characters. The following rules will minimize the symbol length. The rules use the following data character definitions. See Table 2.

control:	Data characters in Code Set A for values 64 through 95 (ASCII values 0 through 31);
standard:	Data characters in Code Set A and B for values 0 through 63 (ASCII values 32 through 95) containing upper case alphabetic, numeric and punctuation. Standard also includes the 4 Code 16K function characters;
numeric:	The digits 0 through 9 (ASCII values 48 through 57);
non-numeric:	Standard characters without the numeric characters;
lower case:	Data characters in Code Set B for values 64 through 95 (ASCII values 96 through 127).

1. Determine the mode m for the starting symbol character from the beginning data characters applying the rules in order until a rule is satisfied:
   a) If FNC 1 is followed by two or more numerics, then m = Code C / FNC 1);
   b) If FNC 1, then m = (Code B / FNC 1);
   c) If an even number of numerics, then m = Code C;
   d) If an odd number of three or more numerics, then m = (Code C / Shift B);
   e) If a non-numeric or lower case character is followed by an even number of numerics, then m = (Code C / Shift B);
   f) If a non-numeric or lower case character is followed by an odd number of three or more numerics, then m = (Code C / Double Shift B);
   g) If a standard or lower case character is followed by a non-numeric or lower case followed by an even number of numerics, then m = (Code C / Double Shift B);
   h) If a control character occurs before a lower case character, then m = Code A;
   i) Otherwise, m = Code B.

2. While a Shift is in effect, encode the data in the shifted Code Set.

3. When in Code Set A, determine the next symbol character D by the data characters remaining to be encoded:
   a) If a lower case character is next and then a control character occurs before another lower case character, then D = Shift B;
   b) If two lower case characters are next and then a control character occurs before another lower case character, then D = Double Shift B;
   c) If a lower case character, then D = Code B;
   d) If four numerics are followed by a non-numeric or control character, then D = Double Shift C;
   e) If six numerics are followed by a non-numeric or control character, then D = Triple Shift C;
   f) If an even number of four or more numerics, then D = Code C;
   g) Otherwise, D = data character.

4. When in Code Set B, determine the next symbol character D by the data characters remaining to be encoded:

a) If a control character is next and then a lower case character occurs before another control character, then D = Shift A;

b) If two control characters are next and then a lower case character occurs before another control character, then D = Double Shift A;

c) If a control character, then D = Code A;

d) If four numerics are followed by a non-numeric or lower case character, then D = Double Shift C;

e) If six numerics are followed by a non-numeric or lower case character, then D = Triple Shift C;

f) If an even number of four or more numerics, then D = Code C;

g) Otherwise, D = data character.

5. When in Code Set C, determine the next symbol character D by the data characters remaining to be encoded:

a) If two or more numerics, then D = the symbol character representing the next two digits;

b) If a FNC 1 character, then D = value 102;

c) If a standard or lower case character is followed by an even number of numerics, then D = Shift B;

d) If a standard or lower case character is followed by an odd number of three or more numerics, then D = Double Shift B;

e) If two characters which are either standard or lower case are followed by an even number of numerics, then D = Double Shift B;

f) If two characters which are either standard or lower case are followed by an odd number of three or more numerics, then D = Triple Shift B;

g) If three characters which are either standard or lower case are followed by an even number of numerics, then D = Triple Shift B;

h) If a control character occurs before a lower case character, then D = Code A;

i) Otherwise, D = Code B.