Code 49

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 49 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 49 is a multi-row, continuous, variable length symbology encoding the full ASCII 128-character set. Each row is composed of 18 bars and 17 spaces. There are between 2 and 8 adjacent rows, each divided by a separator bar. Each row contains a row number, and the last row contains information indicating how many rows there are in the symbol. The main characteristics of Code 49 are presented in Table 1.

Figure 1
Code 49 Symbol Encoding
"MULTIPLE ROWS IN CODE 49"

Encodable Character Set:	All 128 ASCII Characters 3 Non-Data Function Characters 2 Shift Characters 1 Pad/Numeric Shift
Code Type	Multi-Row, Continuous
Row Self-Checking	Yes
Symbol Self-Checking	Yes
Symbol Width	81X with Quiet Zones
Symbol Height	Variable (2 to 8 rows)
Bidirectional Decoding	Yes
Number of Required Symbol Check Characters	2 or 3
Smallest Nominal Element	0.0075 inch (0.191 mm)
Data Capacity	2 row symbol 9 alphanummeric, 15 numeric 8 row symbol 49 alphanumeric, 81 numeric

Table 1
Characteristics of Code 49

2.0 Symbol Description

2.1 Symbol Structure

Each Code 49 symbol consists of 2 to 8 rows. Each row consists of a leading quiet zone, a start pattern, 4 symbol characters encoding 8 code characters (the last code character is a row check character), a stop pattern, and a trailing quiet zone.

Rows are 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. Figure 1 illustrates a Code 49 symbol encoding the data "MULTIPLE ROWS IN CODE 49".

2.1.1 Symbol and Code Characters

Each row contains four symbol characters each with 16 modules forming 4 bars and 4 spaces. Each bar or space may be 1 to 6 modules wide. Each symbol character begins with a bar and ends with a space. Figure 2 illustrates a typical row, including the start and stop patterns.

START STOP
Symbol Character 1 Symbol Character 2 Symbol Character 3 Symbol Character 4

Figure 2
Code 49 Symbol Row

Each symbol character encodes two code characters from a set of 49 code characters. Each code character has a value between 0 to 48. (See Section 2.2 for a description of how code characters represent data.)

The symbol character value (W) is equal to the value of the second code character (C_2) plus 49 times the value of the first code character (C_1). Each symbol character can have a value from 0 to 2400.

$$W = 49C_1 + C_2$$

Formula 1
Symbol Character Value

Each symbol character can be encoded in either even or odd parity. Symbol character parity is based on the sum of the modules in the bars. If the sum of the bar modules is even, the symbol character has even parity; if odd, parity is odd. The symbol character values and corresponding bar and space module counts are given in Appendix F.

The individual rows are uniquely identified by the parity of the symbol characters within the row, as shown in Table 2.

	Symbol Character			
	W1	W2	W3	W4
Row 1	odd	even	even	odd
Row 2	even	odd	even	odd
Row 3	odd	odd	even	even
Row 4	even	even	odd	odd
Row 5	odd	even	odd	even
Row 6	even	odd	odd	even
Row 7	odd	odd	odd	odd
Last Row	even	even	even	even

Table 2
Row Parity Pattern for Code 49 Symbols

Regardless of the number of rows in the symbol, the last row is always encoded with even parity symbol characters.

The code characters encoded in a Code 49 symbol can be described in matrix notation as shown in Table 3. For example, C_{11} and C_{12} are the first and second code characters in the first symbol character in Row 1. C_{13} and C_{14} are the first and second code characters in the second symbol character in Row 1.

	W1		W2		W3		W4	
Row 1	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}
Row 2	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{26}	C_{27}	C_{28}
.								
.								
.								
Row r	C_{r1}	C_{r2}	C_{r3}	C_{r4}	C_{r5}	C_{r6}	C_{r7}	C_{r8}

Table 3
Code 49 Code Character Matrix

In Table 3, r represents the last row in the symbol and has a value between 2 and 8.

2.1.2 Row Check Characters

The last code character in every row is equal to the modulo 49 sum of the other 7 code characters in the row.

2.1.3 Row Count and Mode Character

C_{r7} defines the number of rows in the symbol and the starting mode of the symbol. C_{r7} is calculated as follows:

C_{r7} = 7(r-2)+M, where
r is the number of rows
M is the starting mode

M has a value from 0 to 6 and is defined in Section 2.2.1.

2.1.4 Symbol Check Characters

The symbol characters can be shown in a matrix notation, as illustrated in Table 4.

Symbols with 6 or less rows have two overall symbol check characters, W_{r3} and W_{r2}. Symbols with 7 or 8 rows have an additional symbol check character, W_{r1}.

Check characters W_{r3}, W_{r2} and W_{r1} are weighted check sums, calculated as illustrated in Formula 2.

W_{11}	W_{12}	W_{13}	W_{14}
W_{21}	W_{22}	W_{23}	W_{24}
:			
W_{r1}	W_{r2}	W_{r3}	W_{r4}

Table 4
Code 49 Symbol Character Notation
(Matrix Format)

$$W_{r1}=(Z_{00}C_{r7}+\sum_{i=1}^{r-1}\sum_{j=1}^{4}Z_{ij}W_{ij})\text{MOD } 2401$$

$$W_{r2}=(Y_{00}C_{r7}+\sum_{i=1}^{r-1}\sum_{j=1}^{4}Y_{ij}W_{ij}+Y_{r1}W_{r1})\text{MOD } 2401$$

$$W_{r3}=(X_{00}C_{r7}+\sum_{i=1}^{r-1}\sum_{j=1}^{4}X_{ij}W_{ij}+X_{r1}W_{r1}+X_{r2}W_{r2})\text{MOD } 2401$$

Formula 2
Symbol Check Character Calculation

In Formula 2, X_{ij}, Y_{ij} and Z_{ij} are weighting factors from Table 5.

2.1.5 Start and Stop Patterns

The start and stop pattern is used to identify the leading and trailing ends of the bar code symbol. Code 49 has unique start and stop patterns which identify the nominal beginning and end of the symbol row, allowing it to be bidirectionally scanned.

The start pattern consists of a bar 1 module wide followed by a space 1 module wide. The stop pattern consists of a bar 4 modules wide.

Row i	Col j	X_{ij}	Y_{ij}	Z_{ij}
0	0	20	16	38
1	1	1	9	31
1	2	9	31	26
1	3	31	26	2
1	4	26	2	12
2	1	2	12	17
2	2	12	17	23
2	3	17	23	37
2	4	23	37	18
3	1	37	18	22
3	2	18	22	6
3	3	22	6	27
3	4	6	27	44
4	1	27	44	15
4	2	44	15	43
4	3	15	43	39
4	4	43	39	11
5	1	39	11	13
5	2	11	13	5
5	3	13	5	41
5	4	5	41	33
6	1	41	33	36
6	2	33	36	8
6	3	36	8	4
6	4	8	4	32
7	1	4	32	3
7	2	32	3	19
7	3	3	19	40
7	4	19	40	25
8	1	40	25	29
8	2	25	29	10
8	3	29	10	24
8	4	10	24	30

Table 5
Check Character Weighting Values

2.2 Data Encodation

Data can be encoded with three different methods. These methods are alphanumeric, numeric-only and full ASCII.

2.2.1 Alphanumeric Encodation Method

In alphanumeric encodation, every code character represents a single data character or special character. Table 6 defines this encodation.

Code Character Value	Code Character	Code Character Value	Code Character
0	0	25	P
1	1	26	Q
2	2	27	R
3	3	28	S
4	4	29	T
5	5	30	U
6	6	31	V
7	7	32	W
8	8	33	X
9	9	34	Y
10	A	35	Z
11	B	36	-
12	C	37	.
13	D	38	space
14	E	39	$
15	F	40	/
16	G	41	+
17	H	42	%
18	I	43	S1 (Shift 1)
19	J	44	S2 (Shift 2)
20	K	45	FNC 1 (Function 1)
21	L	46	FNC 2 (Function 2)
22	M	47	FNC 3 (Function 3)
23	N	48	<NS> (numeric shift)
24	O		

Table 6
CODE 49 Code Character Set

NOTE: The complete encodation pattern of the 16 modules which comprise each symbol character is found in Appendix F.

Alphanumeric encodation includes six non-data characters: Shift 1, Shift 2, FNC 1, FNC 2, FNC 3 and <NS>.

Shift 1 and Shift 2 are used as the first character in a code character pair to define full-ASCII characters as shown in Table 7.

Special meaning has been assigned to the use of FNC 1 or FNC 2 in a symbol:

FNC 1 - Alternate Symbol Type Identifier
FNC 2 - Field Separator
FNC 3 - Reserved

The use of the FNC 1 character as the first code character in the first symbol character 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]T1 if the symbology prefix is enabled in the reader. (See section 2.4.2.) Readers should allow Code 49 with FNC 1 in the first position to be enabled separately from normal Code 49 symbols.

The FNC 2 character is used to separate two adjacent fields of data in a Code 49 symbol. This allows a single Code 49 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 FNC 2 character is in the first data character position, it will cause the reader to transmit a symbology identifier prefix option of]T4 (if the symbology identifier prefix is enabled in the reader). This can be used to designate another industry specific Code 49 symbol similar to FNC 1.

The numeric shift <NS> character has two functions. Whenever the numeric shift character is encountered within the code characters encoding data, it serves to toggle between Alphanumeric encodation and Numeric encodation. When one or more numeric shifts appear immediately preceding the symbol check characters, they are pad characters and do not represent data.

2.2.2 Numeric Encodation Method

Long sequences of numeric digits can be compressed through the use of the Numeric encodation method.

When using the Numeric encodation method, five digits are represented as three code characters, using the subset of code characters 0 through 47. If C_1, C_2, and C_3 represent the three code characters, the encoded Numeric value is equal to $48^2C_1 + 48C_2 + C_3$.

Whenever the number of digits to be encoded is a multiple of 5 plus 1, the last digit is represented by a single code character from Table 6.

ASCII	CODE 49	ASCII	CODE 49	ASCII	CODE 49	ASCII	CODE 49
Null	S1 Sp	Space	Sp	@	S2 6	`	S2 .
SOH	S1 A	!	S1 6	A	A	a	S2 A
STX	S1 B	"	S1 7	B	B	b	S2 B
ETX	S1 C	#	S1 8	C	C	c	S2 C
EOT	S1 D	$	$	D	D	d	S2 D
ENQ	S1 E	%	%	E	E	e	S2 E
ACK	S1 F	&	S1 9	F	F	f	S2 F
BEL	S1 G	'	S1 0	G	G	g	S2 G
BS	S1 H	(	S1 -	H	H	h	S2 H
HT	S1 I	)	S1 .	I	I	i	S2 I
LF	S1 J	*	S1 $	J	J	j	S2 J
VT	S1 K	+	+	K	K	k	S2 K
FF	S1 L	,	S1 /	L	L	l	S2 L
CR	S1 M	-	-	M	M	m	S2 M
SO	S1 N	.	.	N	N	n	S2 N
SI	S1 O	/	/	O	O	o	S2 O
DLE	S1 P	0	0	P	P	p	S2 P
DC1	S1 Q	1	1	Q	Q	q	S2 Q
DC2	S1 R	2	2	R	R	r	S2 R
DC3	S1 S	3	3	S	S	s	S2 S
DC4	S1 T	4	4	T	T	t	S2 T
NAK	S1 U	5	5	U	U	u	S2 U
SYN	S1 V	6	6	V	V	v	S2 V
ETB	S1 W	7	7	W	W	w	S2 W
CAN	S1 X	8	8	X	X	x	S2 X
EM	S1 Y	9	9	Y	Y	y	S2 Y
SUB	S1 Z	:	S1 +	Z	Z	z	S2 Z
ESC	S1 1	;	S2 1	[	S2 7	{	S2 $
FS	S1 2	<	S2 2	\	S2 8	|	S2 /
GS	S1 3	=	S2 3	]	S2 9	}	S2 +
RS	S1 4	>	S2 4	^	S2 0	(tilde)	S2 %
US	S1 5	?	S2 5	_	S2 -	DEL	S2 Sp

Notes:

1. Shift 1 is represented by S1
2. Shift 2 is represented by S2
3. The combination S1 % is not used, but is reserved for future use as an additional function code.

Table 7

Code 49 ASCII Chart

Whenever the number of digits to be encoded is a multiple of 5 plus 3, the last 3 digits are represented by two code characters where the three digit number is equal to $48C_1 + C_2$.

Whenever the total number of digits to be encoded is a multiple of 5 plus 4, the last 4 digits are represented by 3 characters, where where $48^2C_1 + 48C_2 + C_3$ = 100,000 plus the four digits to be represented.

Whenever the total number of digits to be encoded is a multiple of 5 plus 2, the last 7 digits are considered to be 4 followed by 3, and are represented by 3 and 2 characters as shown previously.

Examples:
In the following examples, the numeric data on the left are encoded by the code character values on the right.

1)	12345	5,17,9
2)	123456	5,17,9,6
3)	12345678	5,17,9,14,6
4)	123456789	5,17,9,46,16,37
5)	1234567	43,45,2,11,39

In example 1 above, the calculation is $5 \times 48^2 + 17 \times 48 + 9 = 12345$.

2.2.3 Full ASCII Encodation Method

ASCII characters beyond the basic alphanumeric data character set are encoded as a code character pair where the first character of the pair is either a Shift 1 or a Shift 2 character. Table 7 describes the encodation of the full ASCII character set.

2.3 Starting Modes

Starting mode values are listed in Table 8.

M	Starting Mode
0	Alphanumeric Mode
1	Concatenate Alphanumeric Mode
2	Numeric Mode
3	Group Alphanumeric Mode
4	Alphanumeric Mode, Shift 1
5	Alphanumeric Mode, Shift 2
6	Reserved

Table 8
Starting Mode Values for Code 49

2.3.1 Regular Alphanumeric Mode

Mode 0 indicates that the symbol starts with alphanumeric encodation.

2.3.2 Concatenate Alphanumeric Mode

Mode 1 indicates that the symbol starts with alphanumeric encodation and that the data from the symbol is to be concatenated.

If a Code 49 symbol starts in Mode 1, the reader appends the information to a storage buffer (data not transmitted). The operation continues for all successive symbols starting in Mode 1, with messages being added to the end of previously stored messages. When a symbol is read which is not in Mode 1 or the concatenation event is separately concluded by a reader command, the contents are appended to the buffer, the entire buffer is transmitted, and the buffer is cleared.

2.3.3 Numeric Mode

Mode 2 indicates that the symbol starts with numeric encodation.

2.3.4 Group Alphanumeric Mode

Mode 3 indicates that the symbol starts in alphanumeric encodation and is to be concatenated using the group method.

Symbols which start in Mode 3 provide a more strongly controlled form of concatenation. It allows multiple symbols to be concatenated into a single message, retaining data in the correct order, regardless of scanning sequence.

Each symbol to be included in the Group concatenation is printed with Starting Mode 3. The first data character indicates how many symbols are in the group and that symbol's sequential number according to Table 9. The maximum number of symbols in a group is 9.

For example, if the first code character of a Mode 3 symbol is 25 then the symbol is the fifth symbol in a group of seven.

The following example illustrates Group Mode. Consider the text:

CODE 49 IS A MULTI-ROW, CONTINUOUS, VARIABLE LENGTH SYMBOLOGY ENCODING THE FULL ASCII 128-CHARACTER SET. EACH ROW CONTAINS 18 BARS.

Symbol Number	Group Size	First Code Character Value	First Code Character Data
1	2	1	1
2	2	2	2
1	3	3	3
2	3	4	4
3	3	5	5
1	4	6	6
2	4	7	7
3	4	8	8
4	4	9	9
1	5	10	A
2	5	11	B
3	5	12	C
4	5	13	D
5	5	14	E
1	6	15	F
2	6	16	G
3	6	17	H
4	6	18	I
5	6	19	J
6	6	20	K
1	7	21	L
2	7	22	M
3	7	23	N
4	7	24	O
5	7	25	P
6	7	26	Q
7	7	27	R
1	8	28	S
2	8	29	T
3	8	30	U
4	8	31	V
5	8	32	W
6	8	33	X
7	8	34	Y
8	8	35	Z
1	9	36	-
2	9	37	.
3	9	38	space
4	9	39	$
5	9	40	/
6	9	41	+
7	9	42	%
8	9	43	Shift 1
9	9	44	Shift 2

Table 9
Mode 3 First Character

Encoding this text in Group Mode produces three Code 49 symbols with data characters arranged as follows:

Mode=3	3	C	O	D	E		4
	9		I	S		A	
	M	U	L	T	I	-	R
	O	W	,		C	O	N
	T	I	N	U	O	U	S
	,		V	A	R	I	A
	B	L	E		L	E	N
Mode=3	4	G	T	H		S	Y
	M	B	O	L	O	G	Y
		E	N	C	O	D	I
	N	G			T	H	E
	F	U	L	L		A	S
	C	I	I		1	2	8
	-	C	H	A	R	A	C
Mode=3	5	T	E	R		S	E
	T	.			E	A	C
	H		R	O	W		C
	O	N	T	A	I	N	S
		1	8		B	A	R
	S	.					

The above symbols could be scanned in any order. If all three symbols decode properly, the reader will output the data in proper sequence.

2.3.5 *Alphanumeric Mode, Shift 1*

In Mode 4, the symbol starts with alphanumeric encodation with an implied Shift 1 character.

2.3.6 *Alphanumeric Mode, Shift 2*

In Mode 5, the symbol starts with alphanumeric encodation with an implied Shift 2 character.

2.3.7 *Symbol Example*

The steps involved in encoding the data "EXAMPLE 2" are as follows:

1) Determine the character values for the first row.

E = 14 C_{11}] W_1
X = 33 C_{12}
A = 10 C_{13}] W_2
M = 22 C_{14}
P = 25 C_{15}] W_3
L = 21 C_{16}
E = 14 C_{17}

139

2) Determine the check character for Row 1:

$C18 = 139 \text{ MOD } 49 = 41$

3) The data character values for the second row are:

space	= 38	C_{21}	] W_{21}
2	= 2	C_{22}	

In this example, the data message fits exactly into a two row symbol. If a message does not fill all of the available character positions, it is "padded out" using trailing <NS> characters.

4) This is a regular, alphanumeric two-row symbol, therefore

$C_{27} = 7(2\text{-}2) + 0 = 0$

5) Calculate the symbol character values:

14 x 49 + 33 = 719	W_{11}
10 x 49 + 22 = 512	W_{12}
25 x 49 + 21 = 1246	W_{13}
14 x 49 + 41 = 727	W_{14}
38 x 49 + 2 = 1864	W_{21}

6) Calculate the symbol check characters:

W_{22} = [(16x0) + (9x719) + (31x512) + (26x1246) + (2x727) + (12x1864)] MOD 2401 = (78,561) MOD 2401 = 1729

W_{23} = [(20x0) + (1x719) + (9x512) + (31x1246) + (26x727) + (2x1864) + (12x1729)] MOD 2401 = (87,331) MOD 2401 = 895

7) Symbol check characters W_{22} and W_{23} are broken into their components:

W_{22} = 1729 = 49x35+14
W_{23} = 895 = 49x18+13

8) Calculate the check character for the second row:

C_{28} = (38+2+35+14+18+13+0) MOD 49 = 22

9) Calculate the final symbol character:
0 x 49 + 22 = 22 W_{24}

10) The matrix of code characters is:

14	33	10	22	25	21	14	41
38	2	35	14	18	13	0	22

11) The matrix of symbol characters is:

719	512	1246	727
1864	1729	895	22

12) The matrix of symbol character parities is:

odd	even	even	odd
even	even	even	even

13) Appendix F is then used to determine the actual bar and space patterns, which are printed in a complete Code 49 symbol as follows in Figure 3.

Figure 3
Code 49 Symbol
Encoding the Data "EXAMPLE 2"

2.4 Transmitted Data

2.4.1 Data Characters

All decoded characters are included in the data transmission. The Mode Character, Numeric Shift, Function, Shift Characters and Check Characters are not transmitted.

2.4.2 Symbology Identifier Prefix

A symbology identifier prefix may be transmitted by the reader to identify the symbology read and any options. For Code 49, the symbology identifiers are:

]T0	No special characters in first or second data character positions
]T1	FNC 1 in first data character position
]T2	FNC 1 in second data character position
]T4	FNC 2 in first data character position

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

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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 49 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 E 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 symbol character. The bar measurement applies to the start and stop patterns.

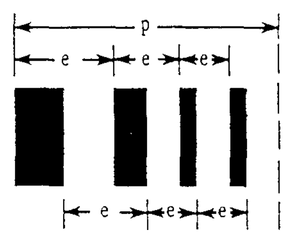

Figure 4

Symbol 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 six indicated dimensions (e) may vary from their nominal dimensions. These six 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.

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 10 lists the calculated tolerances for various X dimensions.

These tolerances are represented graphically in Figure 5.

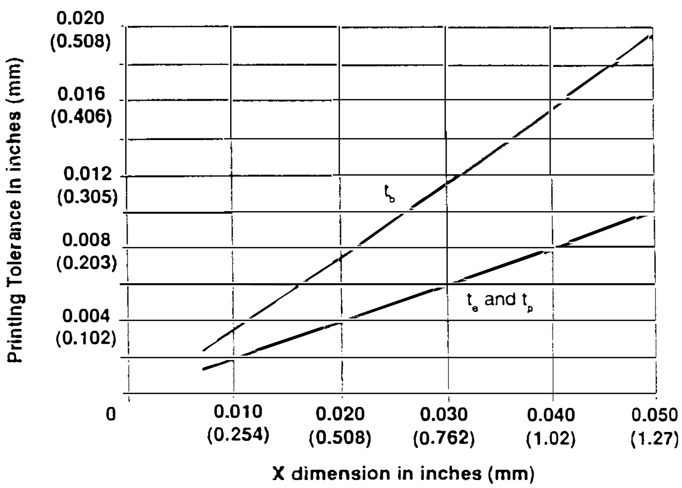

Figure 5
Code 49 Tolerance Values
Graph

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 10 X 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 8)
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 10
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 E 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.

4.4 Reflectance Specifications

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

4.4.1 Minimum 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.

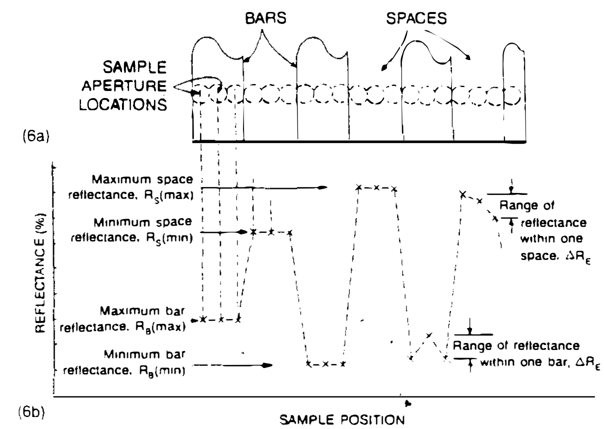

Figure 6
Bar Code Reflectance Measurements

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 on-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, ΔR_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;

ΔR_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.

Appendix B

Reference Decode Algorithm for USS-49

A) For each row:

1) Confirm that the bar count is equal to 18.

2) Confirm the presence of leading and trailing quiet zones.

3) Confirm the presence of a valid start and stop pattern.

4) Code 49 is designed to be decoded using "edge to similar edge" measurements. Take 7 width measurements of every symbol character that is being decoded.

These measurements are called p, t1, t2, t3, t4, t5, and t6, as defined in Figure B-1.

5) Convert the six measurements t1...t6 into corresponding normalized values T1, T2...T6, in terms of integer multiples of a module width, as follows:

If 1.5p/16 ≤ ti < 2.5p/16, then Ti is declared as 2 modules
If 2.5p/16 ≤ ti < 3.5p/16, then Ti is declared as 3 modules
If 3.5p/16 ≤ ti < 4.5p/16, then Ti is declared as 4 modules
If 4.5p/16 ≤ ti < 5.5p/16, then Ti is declared as 5 modules
If 5.5p/16 ≤ ti < 6.5p/16, then Ti is declared as 6 modules
If 6.5p/16 ≤ ti < 7.5p/16, then Ti is declared as 7 modules
If 7.5p/16 ≤ ti < 8.5p/16, then Ti is declared as 8 modules
If 8.5p/16 ≤ ti < 9.5p/16, then Ti is declared as 9 modules,
If 9.5p/16 ≤ ti < 10.5p/16, then Ti is declared as 10 modules,
Otherwise the symbol character is in error.

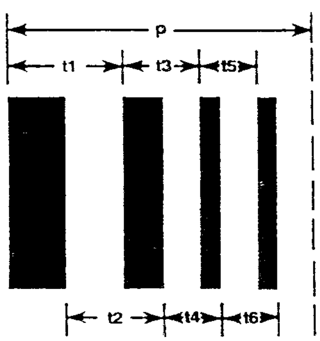

Figure B-1
Tolerance Measurement Definitions

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6) Use the six values T1, T2...T6 to determine a single Code 49 symbol character. (Note: a Code 49 Reference Diskette containing information to facilitate the creation of the appropriate look-up tables is available from AIM USA.)

7) Decode all four symbol characters using the approach outlined in steps (4) through (6), assuming a constant scanning direction.

8) Identify the row number by checking the symbol character parity patterns.

9) Convert the symbol character values into code character values.

10) Confirm that the row check character is correct.

B) Identify the last row which has four symbol characters with even parity, and examine the second to last character. Confirm that the expected number of rows is equal to the number actually observed.

C) Verify that the symbol check characters are correct.

D) Interpret the code characters as data characters according to the mode character and shift characters.

E) Perform such other checks as beam acceleration, absolute timing dimensions, etc., as are deemed prudent and appropriate considering the specific reading device and intended application environment.

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Appendix C

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.

ABCDEFGHIJKLMNOPQRSTUVW

Appendix D

Autodiscrimination Compatibility

Some readers may be programmed to automatically discriminate among symbols encoded in other symbologies. Code 49 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 16K
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 E

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 F — Code 49 Encodation Patterns

A reference diskette containing this table, and the programs necessary to generate it, is available from AIM USA.

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
0	11521132	22121116
1	25112131	42121114
2	14212132	31221115
3	25121221	51221113
4	14221222	32112115
5	12412132	52112113
6	23321221	21212116
7	12421222	41212114
8	21521221	61212112
9	15112222	23121115
10	15121312	43121113
11	13312222	12221116
12	24221311	32221114
13	13321312	52221112
14	11512222	21321115
15	22421311	41321113
16	11521312	61321111
17	25112311	13112116
18	14212312	33112114
19	23312311	22212115
20	12412312	42212113
21	21512311	11312116
22	16121131	31312114
23	14321131	51312112
24	12521131	24121114
25	15212131	13221115
26	15221221	33221113
27	13412131	22321114
28	13421221	42321112
29	11612131	11421115
30	16112221	31421113
31	16121311	51421111
32	14312221	14112115
33	14321311	34112113
34	12512221	23212114
35	12521311	43212112
36	15212311	12312115
37	13412311	32312113
38	11612311	52312111
39	11131135	21412114
40	31131133	41412112
41	51131131	25121113
42	21122134	14221114
43	41122132	34221112
44	21131224	23321113
45	41131222	43321111
46	11113135	12421114
47	31113133	32421112
48	51113131	21521113
49	11122225	41521111
50	31122223	15112114
51	51122221	24212113
52	11131315	13312114
53	31131313	33312112
54	51131311	22412113
55	21113224	42412111
56	41113222	11512114
57	21122314	31512112
58	41122312	15221113
59	11113315	24321112
60	31113313	13421113
61	51113311	33421111
62	12131134	22521112
63	32131132	16112113
64	21231133	25212112

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
65	41231131	14312113
66	22122133	34312111
67	42122131	23412112
68	11222134	12512113
69	22131223	32512111
70	42131221	21612112
71	11231224	21131116
72	31231222	41131114
73	12113134	61131112
74	32113132	31122115
75	12122224	51122113
76	32122222	21113116
77	12131314	41113114
78	32131312	61113112
79	21231313	22131115
80	41231311	42131113
81	22113223	11231116
82	42113221	31231114
83	11213224	51231112
84	22122313	12122116
85	42122311	32122114
86	11222314	52122112
87	31222312	21222115
88	12113314	41222113
89	32113312	61222111
90	21213313	22113115
91	41213311	42113113
92	13131133	11213116
93	33131131	31213114
94	22231132	51213112
95	11331133	23131114
96	31331131	43131112
97	23122132	12231115
98	12222133	32231113
99	23131222	52231111
100	12231223	21331114
101	32231221	41331112
102	21331222	13122115
103	13113133	33122113
104	33113131	22222114
105	13122223	42222112
106	33122221	11322115
107	11313133	31322113
108	13131313	51322111
109	33131311	23113114
110	11322223	43113112
111	22231312	12213115
112	11331313	32213113
113	31331311	52213111
114	23113222	21313114
115	12213223	41313112
116	23122312	24131113
117	12222313	13231114
118	32222311	33231112
119	21322312	22331113
120	13113313	42331111
121	33113311	11431114
122	22213312	31431112
123	11313313	14122114
124	31313311	34122112
125	14131132	23222113
126	23231131	43222111
127	12331132	12322114
128	21431131	32322112
129	24122131	21422113

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
130	13222132	41422111
131	24131221	24113113
132	13231222	13213114
133	11422132	33213112
134	22331221	22313113
135	11431222	42313111
136	14113132	11413114
137	14122222	31413112
138	12313132	25131112
139	14131312	14231113
140	12322222	34231111
141	23231311	23331112
142	12331312	12431113
143	21431311	32431111
144	24113221	15122113
145	13213222	24222112
146	24122311	13322113
147	13222312	33322111
148	11413222	22422112
149	22322311	11522113
150	11422312	31522111
151	14113312	25113112
152	23213311	14213113
153	12313312	34213111
154	21413311	23313112
155	15131131	12413113
156	13331131	32413111
157	14222131	21513112
158	14231221	15231112
159	12422131	24331111
160	12431221	13431112
161	15113131	16122112
162	15122221	25222111
163	13313131	14322112
164	15131311	23422111
165	13322221	12522112
166	11513131	15213112
167	13331311	24313111
168	11522221	13413112
169	14213221	22513111
170	14222311	11613112
171	12413221	21141115
172	12422311	41141113
173	15113311	61141111
174	13313311	11132116
175	11513311	31132114
176	11141134	51132112
177	31141132	21123115
178	21132133	41123113
179	41132131	61123111
180	21141223	11114116
181	41141221	31114114
182	11123134	51114112
183	31123132	22141114
184	11132224	42141112
185	31132222	11241115
186	11141314	31241113
187	31141312	51241111
188	21114133	12132115
189	41114131	32132113
190	21123223	52132111
191	41123221	21232114
192	21132313	41232112
193	41132311	22123114
194	11114224	42123112

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
195	31114222	11223115
196	11123314	31223113
197	31123312	51223111
198	21114313	12114115
199	41114311	32114113
200	12141133	52114111
201	32141131	21214114
202	21241132	41214112
203	22132132	23141113
204	11232133	43141111
205	22141222	12241114
206	11241223	32241112
207	31241221	21341113
208	12123133	41341111
209	32123131	13132114
210	12132223	33132112
211	32132221	22232113
212	12141313	42232111
213	32141311	11332114
214	21241312	31332112
215	22114132	23123113
216	11214133	43123111
217	22123222	12223114
218	11223223	32223112
219	22132312	21323113
220	11232313	41323111
221	31232311	13114114
222	12114223	33114112
223	32114221	22214113
224	12123313	42214111
225	32123311	11314114
226	21223312	31314112
227	22114312	24141112
228	11214313	13241113
229	31214311	33241111
230	13141132	22341112
231	22241131	14132113
232	11341132	34132111
233	23132131	23232112
234	12232132	12332113
235	23141221	32332111
236	12241222	21432112
237	21341221	24123112
238	13123132	13223113
239	13132222	33223111
240	11323132	22323112
241	13141312	11423113
242	11332222	31423111
243	22241311	14114113
244	11341312	34114111
245	23114131	23214112
246	12214132	12314113
247	23123221	32314111
248	12223222	21414112
249	23132311	25141111
250	12232312	14241112
251	21332311	23341111
252	13114222	15132112
253	13123312	24232111
254	11314222	13332112
255	22223311	22432111
256	11323312	25123111
257	23114311	14223112
258	12214312	23323111
259	21314311	12423112

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
260	14141131	21523111	327	11224312	24151111	394	11211325	13116112	461	15111412	23411122
261	12341131	15114112	328	13151131	13251112	395	31211323	22216111	462	24211411	12511123
262	13232131	24214111	329	12242131	14142112	396	51211321	11316112	463	13311412	32511121
263	13241221	13314112	330	12251221	23242111	397	12111415	14152111	464	22411411	21611122
264	11432131	22414111	331	13133131	12342112	398	32111413	13243111	465	11511412	15211213
265	14123131	11514112	332	13142221	24133111	399	52111411	14134111	466	15211141	24311212
266	14132221	15241111	333	11333131	13233112	400	21211414	12334111	467	13411141	13411213
267	12323131	16132111	334	13151311	22333111	401	41211412	13225111	468	11611141	33411211
268	14141311	14332111	335	11342221	11433112	402	12211144	11425111	469	16111231	22511212
269	12332221	15223111	336	12224131	14124112	403	32211142	14116111	470	14311231	11611213
270	12341311	13423111	337	12233221	23224111	404	21311143	12316111	471	12511231	31611211
271	13214131	16114111	338	12242311	12324112	405	41311141	41111215	472	15211321	31121125
272	13223221	14314111	339	13115131	21424111	406	13111234	61111213	473	13411321	51121123
273	11414131	12514111	340	13124221	24115111	407	33111232	21211126	474	11611321	21112126
274	13232311	21151114	341	11315131	13215112	408	22211233	41211124	475	16111411	41112124
275	11423221	41151112	342	13133311	22315111	409	42211231	61211122	476	14311411	61112122
276	11432311	11142115	343	11324221	11415112	410	11311234	22111216	477	12511411	21121216
277	14114221	31142113	344	11333311	14251111	411	31311232	42111214	478	21121144	41121214
278	14123311	51142111	345	12215221	15142111	412	23111323	31211215	479	41121142	61121212
279	12314221	21133114	346	12224311	13342111	413	43111321	51211213	480	11112145	31112215
280	12323311	41133112	347	11161132	14233111	414	12211324	22211125	481	31112143	51112213
281	13214311	11124115	348	21152131	12433111	415	32211322	42211123	482	51112141	12121126
282	11414311	31124113	349	21161221	15124111	416	21311323	11311126	483	11121235	32121124
283	11151133	51124111	350	11143132	13324111	417	41311321	31311124	484	31121233	52121122
284	31151131	21115114	351	11152222	11524111	418	13111414	51311122	485	51121231	21221125
285	21142132	41115112	352	11161312	14215111	419	33111412	23111215	486	21112234	41221123
286	21151222	22151113	353	21134131	12415111	420	22211413	43111213	487	41112232	61221121
287	11133133	42151111	354	21143221	21161113	421	42211411	12211216	488	21121324	22112125
288	31133131	11251114	355	21152311	41161111	422	11311414	32211214	489	41121322	42112123
289	11142223	31251112	356	11125132	11152114	423	31311412	52211212	490	11112325	11212126
290	31142221	12142114	357	11134222	31152112	424	13211143	21311215	491	31112323	22121215
291	11151313	32142112	358	11143312	21143113	425	33211141	41311213	492	51112321	42121213
292	31151311	21242113	359	21116131	41143111	426	22311142	61311211	493	11121415	11221216
293	21124132	41242111	360	21125221	11134114	427	11411143	23211124	494	31121413	31221214
294	21133222	22133113	361	21134311	31134112	428	31411141	43211122	495	51121411	51221212
295	21142312	42133111	362	12161131	21125113	429	14111233	12311125	496	21112414	12112216
296	11115133	11233114	363	11252131	41125111	430	34111231	32311123	497	41112412	32112214
297	31115131	31233112	364	12143131	11116114	431	23211232	52311121	498	22121143	52112212
298	11124223	12124114	365	12152221	31116112	432	12311233	21411124	499	42121141	21212215
299	31124221	32124112	366	12161311	22161112	433	32311231	41411122	500	11221144	41212213
300	11133313	21224113	367	11234131	12152113	434	21411232	24111214	501	31221142	61212211
301	31133311	41224111	368	11243221	32152111	435	24111322	13211215	502	12112144	13121125
302	21115222	22115113	369	11252311	21252112	436	13211323	33211213	503	32112142	33121123
303	21124312	42115111	370	12125131	22143112	437	33211321	22311214	504	12121234	22221124
304	12151132	11215114	371	12134221	11243113	438	22311322	42311212	505	32121232	42221122
305	21251131	31215112	372	12143311	31243111	439	11411323	11411215	506	21221233	11321125
306	22142131	23151112	373	11216131	12134113	440	31411321	31411213	507	41221231	31321123
307	11242132	12251113	374	11225221	32134111	441	14111413	51411211	508	22112233	51321121
308	22151221	32251111	375	11234311	21234112	442	34111411	24211123	509	42112231	23112124
309	11251222	13142113	376	11111236	22125112	443	23211412	13311124	510	11212234	43112122
310	12133132	33142111	377	31111234	11225113	444	12311413	33311122	511	22121323	12212125
311	12142222	22242112	378	51111232	31225111	445	32311411	22411123	512	42121321	23121214
312	12151312	11342113	379	21111325	12116113	446	21411412	42411121	513	11221324	43121212
313	21251311	31342111	380	41111323	32116111	447	14211142	11511124	514	31221322	12221215
314	22124131	23133112	381	61111321	21216112	448	23311141	31511122	515	12112324	32221213
315	11224132	12233113	382	11111416	23161111	449	12411142	25111213	516	32112322	52221211
316	22133221	32233111	383	31111414	13152112	450	21511141	14211214	517	12121414	21321214
317	11233222	21333112	384	51111412	22252111	451	15111232	34211212	518	32121412	41321212
318	22142311	13124113	385	31211143	23143111	452	24211231	23311213	519	21221413	13112215
319	11242312	33124111	386	51211141	12243112	453	13311232	43311211	520	41221411	33112213
320	12115132	22224112	387	12111235	21343111	454	22411231	12411214	521	22112413	22212214
321	12124222	11324113	388	32111233	13134112	455	11511232	32411212	522	42112411	42212212
322	12133312	31324111	389	52111231	22234111	456	25111321	21511213	523	11212414	11312215
323	21233311	23115112	390	21211234	11334112	457	14211322	41511211	524	31212412	31312213
324	22115221	12215113	391	41211232	23125111	458	23311321	25211122	525	23121142	51312211
325	11215222	32215111	392	22111324	12225112	459	12411322	14311123	526	12221143	14121124
326	22124311	21315112	393	42111322	21325111	460	21511321	34311121	527	32221141	34121122

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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529	13112143	43221121	596	13312321	51131122	663	11331232	43113211	730	31114321	14313121
530	33112141	12321124	597	13321411	21122125	664	23113141	12213214	731	11123413	14322211
531	13121233	32321122	598	11512321	41122123	665	12213142	32213212	732	31123411	12513121
532	33121231	21421123	599	11521411	61122121	666	23122231	21313213	733	22141141	12522211
533	11312143	41421121	600	14212411	21131215	667	12222232	41313211	734	11241142	15213211
534	22221232	24112123	601	12412411	41131213	668	23131321	14131123	735	12132142	13413211
535	11321233	13212124	602	21131143	61131211	669	12231322	34131121	736	12141232	11613211
536	31321231	24121213	603	41131141	11113126	670	21331321	23231122	737	21241231	11141125
537	23112232	13221214	604	11122144	31113124	671	13113232	12331123	738	22123141	31141123
538	12212233	33221212	605	31122142	51113122	672	13122322	32331121	739	11223142	51141121
539	23121322	11412124	606	11131234	11122216	673	11313232	21431122	740	22132231	21132124
540	12221323	22321213	607	31131232	31122214	674	13131412	24122122	741	11232232	41132122
541	32221321	42321211	608	21113143	51122212	675	11322322	13222123	742	22141321	21141214
542	21321322	11421214	609	41113141	21113215	676	22231411	24131212	743	11241322	41141212
543	13112323	31421212	610	21122233	41113213	677	11331412	13231213	744	12114142	11123125
544	33112321	14112214	611	41122231	61113211	678	23113321	33231211	745	12123232	31123123
545	13121413	34112212	612	21131323	12131125	679	12213322	11422123	746	12132322	51123121
546	33121411	23212213	613	41131321	32131123	680	23122411	22331212	747	12141412	11132215
547	11312323	43212211	614	11113234	52131121	681	12222412	11431213	748	21241411	31132213
548	22221412	12312214	615	31113232	21231124	682	21322411	31431211	749	22114231	51132211
549	11321413	32312212	616	11122324	41231122	683	13113412	14113123	750	11214232	21114124
550	31321411	21412213	617	31122322	22122124	684	22213411	34113121	751	22123321	41114122
551	23112412	41412211	618	11131414	42122122	685	11313412	14122213	752	11223322	21123214
552	12212413	15121123	619	31131412	11222125	686	13231141	34122211	753	22132411	41123212
553	32212411	24221122	620	21113323	22131214	687	11431141	12313123	754	11232412	11114215
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555	24121141	33321121	622	21122413	11231215	689	14131231	12322213	756	12123412	51114211
556	13221142	22421122	623	41122411	31231213	690	12322141	32322211	757	21223411	12141124
557	22321141	11521123	624	11113414	51231211	691	12331231	21422212	758	12241141	32141122
558	11421142	31521121	625	31113412	12113125	692	13213141	24113212	759	13132141	21241123
559	14112142	25112122	626	22131142	32113123	693	13222231	13213213	760	13141231	41241121
560	14121232	14212123	627	11231143	52113121	694	11413141	33213211	761	11332141	22132123
561	12312142	25121212	628	31231141	12122215	695	13231321	22313212	762	11341231	42132121
562	23221231	14221213	629	12122143	32122213	696	11422231	11413213	763	12223141	11232124
563	12321232	34221211	630	32122141	52122211	697	11431321	31413211	764	12232231	22141213
564	21421231	12412123	631	12131233	21222214	698	14113231	15131122	765	12241321	42141211
565	24112231	23321212	632	32131231	41222212	699	14122321	24231121	766	13114141	11241214
566	13212232	12421213	633	21231232	22113214	700	12313231	13331122	767	13123231	31241212
567	24121321	32421211	634	22113142	42113212	701	14131411	22431121	768	11314141	12123124
568	13221322	21521212	635	11213143	11213215	702	12322321	25122121	769	13132321	32123122
569	11412232	15112213	636	22122232	31213213	703	12331411	14222122	770	11323231	12132214
570	22321321	24212212	637	11222233	51213211	704	13213321	25131211	771	13141411	32132212
571	11421322	13312213	638	22131322	13131124	705	13222411	14231212	772	11332321	21232213
572	14112322	33312211	639	11231323	33131122	706	11413321	12422122	773	11341411	41232211
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574	12312322	11512213	641	12113233	42231121	708	14113411	12431212	775	12223321	42114121
575	23221411	31512211	642	32113231	11331124	709	12313411	15113122	776	12232411	11214124
576	12321412	16121122	643	12122323	31331122	710	21141142	15122212	777	13114321	22123213
577	21421411	25221121	644	32122321	23122123	711	11132143	13313122	778	13123411	42123211
578	24112411	14321122	645	12131413	43122121	712	31132141	24222211	779	11314321	11223214
579	13212412	23421121	646	32131411	12222124	713	11141233	13322212	780	11323411	31223212
580	22312411	12521122	647	21231412	23131213	714	31141231	11513122	781	21151141	12114214
581	11412412	15212122	648	22113322	43131211	715	21123142	22422211	782	11142142	32114212
582	14221141	15221212	649	11213323	12231214	716	21132232	11522212	783	11151232	21214213
583	12421141	13412122	650	22122412	32231212	717	21141322	25113211	784	21133141	41214211
584	15112141	24321211	651	11222413	21331213	718	11114143	14213212	785	21142231	13141123
585	15121231	13421212	652	31222411	41331211	719	31114141	23313211	786	21151321	33141121
586	13312141	11612122	653	12113413	13113124	720	11123233	12413212	787	11124142	22241122
587	13321231	22521211	654	32113411	33113122	721	31123231	21513211	788	11133232	11341123
588	11512141	16112212	655	21213412	13122214	722	11132323	16131121	789	11142322	31341121
589	11521231	25212211	656	23131141	33122212	723	31132321	14331121	790	11151412	23132122
590	14212231	14312212	657	12231142	11313124	724	11141413	15222121	791	21115141	12232123
591	14221321	23412211	658	21331141	22222213	725	31141411	15231211	792	21124231	23141212
592	12412231	12512212	659	13122142	42222211	726	21114232	13422121	793	21133321	12241213
593	12421321	21612211	660	13131232	11322214	727	21123322	13431211	794	21142411	32241211
594	15112321	11131126	661	11322142	31322212	728	21132412	16113121	795	11115232	21341212

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
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1870	13113214	22222411	1937	15213121	22141411	2004	23123122	11143141	2071	41133121	23211421
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1875	31313212	14131141	1942	16113211	21232411	2009	21332212	11143321	2076	11133214	22311511
1876	24131122	12331141	1943	14313211	22114321	2010	13114123	11152411	2077	31133212	11411512
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1934	14322121	11223232	2001	22241212	11224321	2068	11151214	22311331	2135	14142121	21212512

Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS	Symbol Char. Value	Parity Even BSBSBSBS	Parity Odd BSBSBSBS
2136	14151211	23121151	2203	51111313	22131151	2270	21511222	11241331	2337	13121134	11411251
2137	12342121	12221152	2204	21211135	11231152	2271	15111313	12114151	2338	33121132	14111341
2138	13233121	21321151	2205	41211133	12122152	2272	24211312	12123241	2339	22221133	12311341
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2141	14124121	11312152	2208	42111223	22113151	2275	22411312	11214241	2342	31321132	14111521
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2145	13215121	12212242	2212	12111316	22131331	2279	14311132	12114331	2346	23121223	31121161
2146	13224211	23121331	2213	32111314	11231332	2280	23411131	12123421	2347	43121221	21112162
2147	11415121	12221332	2214	52111312	12113242	2281	12511132	12132511	2348	12221224	21121252
2148	11424211	21321331	2215	21211315	12122332	2282	21611131	11142151	2349	32221222	11112253
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2163	21134212	11421151	2230	13111315	11322151	2297	41112133	41111431	2364	32212312	11212162
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