BAR CODE STANDARDS

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1. GENERAL

SCOPE

1.01 This practice defines the bar codes adopted for use in AT&T and details their characteristics. These bar codes are intended for data entry/decoding by wand or laser-type scanners.

A. Background

Applications

1.02 The Plug-in Inventory Control/Detailed Continuing Property Record System uses bar code labels as a means of expediting inventory of plug-in equipment and for controlling maintenance and replacement stock levels. Other applications include item inventory, product tracking, and controlled access.

Industry Standards

1.03 The rapid growth in the use of bar code identification has resulted in the publication of American National Standard MH10.8M-1983, controlling content and quality of bar code symbols for transport packages and unit loads. Similar standards were adopted by the federal government detailing bar coding requirements for all equipment and materials furnished by industrial contractors.

Data Entry

1.04 Wanding of bar-coded data allows its expeditious transfer to computerized data bases with a minimum of manual data entry problems such as high error rates and slow speed.

B. Terminology

Bar— The darker element of a bar code.

Bar Code— An array of rectangular marks and spaces in a predetermined pattern.

Bar Code Label— An adhesive-backed carrier bearing bar-coded information, suitable for affixing to an apparatus, equipment, or container surface.

Bar Code Scanner— A device used to convert optical data, ie, bar codes, into electronic signals or digital data.

Bar Code Symbol— A graphic (printed or photographically reproduced) bar code composed of parallel bars and spaces of various widths and intended for use in the detection and automatic processing of item identities or other intelligence by electro-optical means. It characteristically consists of leading and trailing quiet zones, start/stop characters, the encoded data, and a check character(s).

Bidirectional— Relating to the characteristic of some bar codes that allows decoding of their contents whether scanned in one direction or the reverse direction.

Character— A letter, digit, space, punctuation or symbol, or its bar code equivalent, used to convey information.

Check Character— A calculated character included within a message and used for error detection.

Continuous Bar Code Symbol— A bar code symbol which contains no intercharacter space.

Density— The number of bar-coded characters per inch.

Decoder Logic— Electronic circuitry and software which converts scanner data into a binary format and identifies the information content.

Discrete Bar Code Symbol— A bar code symbol in which the intercharacter space is not part of the code.

Edge Error— An irregularity of the straight line transition between bar and contiguous space, eg, smears or voids.

Element— A bar or a space.

First Read Rate— A percentage representing the proportion of the number of successful decodes to the number of scan attempts.

Font— A specific style and size of characters.

Intercharacter Space— For codes 11 and 39, the space between the last bar of one character and the first bar of the next.

Message— A group of characters encoded in the bar code symbol.

Message Length— The number of characters encoded.

Misread— See substitution error.

Modulo Check Character(s)— A means of insuring message accuracy through use of check character(s) that represent the remainder obtained when the summation of character values assigned by the code to the message contents is divided by the number of available encodable characters.

Non-Read— The failure of a bar code scanner to recognize/ decode a bar code symbol after a scanning attempt. Such may result from bar code defects, scanner defects, or operator error, eg, incomplete scan of symbol.

OCR-B— A human and machine readable alphanumeric character set in which each and every character is identifiable by itself. See American National Standard X3.49-1975.

Quiet Zone— The area immediately preceding the start character and following the stop character, and which contains no markings.

Reflectance— The ratio, usually expressed as a decimal, of the amount of light reflected from a surface to the amount incident on that surface, usually detailed under a given set of illumination conditions.

Space— The lighter element of a bar code.

Start/Stop Characters— Distinct characters used at the beginning and end of each bar code symbol which provide initial timing references and direction-of-read information to the decoding logic.

Substitution Error— The replacement of a bar coded character(s), by an erroneous character(s) usually traceable to poor quality printing, decoding logic error, human input error, or any combination of these.

Transport Package— A package intended for the transportation and handling of one or more articles, smaller packages, or bulk material.

Unit Load— One or more filled transport packages or other items held together by one or more means such as pallet, slip sheet, strapping, interlocking, glue, shrink wrap, stretch wrap, or net wrap, making them suitable for transport, stacking, and storage as unit.

Void(s)— The absence of ink within a printed bar or character.

2. REQUIREMENTS

BAR CODE APPLICATIONS

2.01 AT&T applications requiring bar code labels for identification shall use Code 11 or Code 39.

A. Code 11

2.02 Use of this code is limited to numeric applications.

Content

2.03 The name of the code is derived from the fact that, excluding the start/stop symbol, the character repertoire consists of 11 characters, 10 numeric (0-9) and a dash. Each Code 11 character consists of five elements, three of which are bars separated by two spaces. One or two elements of each character are wide elements. Each character is separated from the next by an intercharacter space. Code design is such that each character has exactly the same width. This width consistency means that in those characters containing only one wide element, the wide element must necessarily be approximately 50 percent wider. The inclusion of one or two check characters in each symbol guards against substitution errors.

Dimensions

2.04 The narrow elements of the bar code (bar or space) are 0.0075 inch wide and the wide elements are 0.0168 inch wide. However, in characters containing only one wide element, ie, 0, 9 and -, the wide bar used is 0.0261 inch wide in order to insure a constant character width of 0.0561 inch. This results in a symbol density of 15 characters per inch. Intercharacter space is 0.011 inch. The height of the bar code is generally a function of the symbol length. Under normal circumstances the minimum height is 0.20 inch or 15 percent of the symbol length, whichever is greater.

Code Structure

2.05 Code 11 characters are defined by the structure shown in Fig 1.

Tolerances

2.06 The width of each bar and space shall conform to the dimensions specified in Fig 1 within a tolerance of plus or minus 0.0015 inch.

Check Character

2.07 The check character algorithm used with Code 11 is a weighted modulo 11 character. In most current applications the present check character suffices. However, when applications greater than 9 digits are encoded, the use of additional check characters should merit consideration. The modulo 11 derivation consists of the following procedural steps:

(a) Each character of the encoded message, excluding the start/stop and check characters, is assigned a value in accordance with Table A.

(b) Each character of the encoded message is assigned a sequential weight value depending on its position from right to left, eg, 1, 2, 3,...

(c) Each character value is multiplied by its positional weight and the result added to the results for the other characters of the message.

ENCODED CHARACTER	BINARY PATTERN	CHARACTER SYMBOL	DIMENSIONS (10^{-4} INCH)				
	B S B S B		B	S	B	S	B
1	1 0 0 0 1		168	75	75	75	168
2	0 1 0 0 1		75	168	75	75	168
3	1 1 0 0 0		168	168	75	75	75
4	0 0 1 0 1		75	75	168	75	168
5	1 0 1 0 0		168	75	168	75	75
6	0 1 1 0 0		75	168	168	75	75
7	0 0 0 1 1		75	75	75	168	168
8	1 0 0 1 0		168	75	75	168	75
9	1 0 0 0 0		261	75	75	75	75
0	0 0 0 0 1		75	75	75	75	261
-	0 0 1 0 0		75	75	261	75	75
*	0 0 1 1 0		75	75	168	168	75

Fig 1 - Code 11 Code Structure

(d) The resulting total is divided by 11.

(e) The remainder of the division process is encoded as the check character using Table A.

(f) The following example illustrates the check character derivation:

(1) Assume that the message data to be encoded were:

5 2 1 6 0 4 - -

(2) Referring to Table A, the respective character values become:

5, 2, 1, 6, 0, 4, 10, 10

(3) The positional weights assigned become, respectively:

8, 7, 6, 5, 4, 3, 2, 1

(4) Multiplying the value and weight for each character, the products become:

Data	Value (V)	Weight (W)	Product(VxW)
5	5	8	40
2	2	7	14
1	1	6	6
6	6	5	30
0	0	4	0
4	4	3	12
-	10	2	20
-	10	1	10
			132

(5) Division by 11 results in 12 with a remainder of 0.

(6) The remainder of 0 becomes the check character, and encoding per Table A yields a character of 0.

(7) The final message to be bar coded becomes:

S/S 5 2 1 6 0 4 - - 0 S/S

TABLE A
CODE 11 CHARACTER VALUES

S/S 521604--05/S	
Character	Value
0	0
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
-	10
S/S(*)	-

B. Code 39

2.08 This code is used within AT&T for all alphanumeric applications, and for numeric applications where space is not a constraint.

Content

2.09 The name of the code is derived from the characteristic that three of the nine elements are wide elements. Each Code 39 character consists of nine elements, five of which are bars separated by spaces. The character repertoire consists of 10 numerals (0-9), 26 letters (A-Z), a space, a start/stop symbol (*), and six symbols (-.$/+%). Each character is separated from the next by an intercharacter space. Each character has exactly the same width. The code is considered self-checking because the structure of each character allows testing for errors. The inclusion of check character(s) provides additional checks against substitution errors.

Dimensions

2.10 Element and intercharacter space widths are dictated by the code density employed in the application. See Table B. The height of the bar code symbol is a function of its length and the scanning means used, ie, contact or remote scanning. In contact scanning applications the height of the bars should be minimum 0.20 inch, but not less than 15 percent of the symbol length. In fixed-base, remote scanning on transport packages, the height of the bars should be minimum 0.80 inch, but not less than 25 percent of the symbol length. Applications using both scanning means should apply the remote criteria.

TABLE B
CODE 39 WIDTH PARAMETERS

Code Density (Char/Inch)	Nominal Width (Inch)			Width Tolerance (Inch)
	Narrow Elem.	Wide Elem.	Intercharacter Space	
9.4	0.0075	0.0169	0.011	0.0017
5.4	0.0115	0.0345	0.017	0.0040
3.0	0.0200	0.0600	0.030	0.0069
1.7	0.0400	0.1000	0.060	0.0110
0.85	0.0800	0.2000	0.120	0.0220

Code Structure

2.11 Code 39 characters are defined by the structure shown in Fig 2.

Tolerances

2.12 The widths of each bar and space shall conform to the dimensions and tolerances specified in Table B.

Check Character

2.13 Where applications recognize alternative inputs such as manual keying, the weighted modulo 43 check character may be used. The weighted modulo 43 derivation consists of the following procedural steps:

(a) Each character of the encoded message, excluding the start/stop and check characters, is assigned a value in accordance with Table C.

(b) Each character of the encoded message is assigned a sequential weight value depending on its position from right to left, eg, 1, 2, 3,...

(c) Each characters value is multiplied by its positional weight, and the result is added to the result for the other character of the message.

(d) The resulting total is divided by 43.

(e) The remainder of the division process is encoded as the check character using Table C.

(f) The following example illustrates the check character derivation:

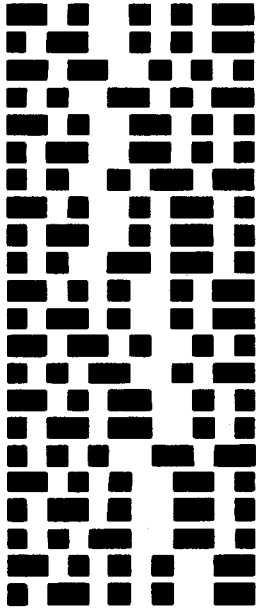
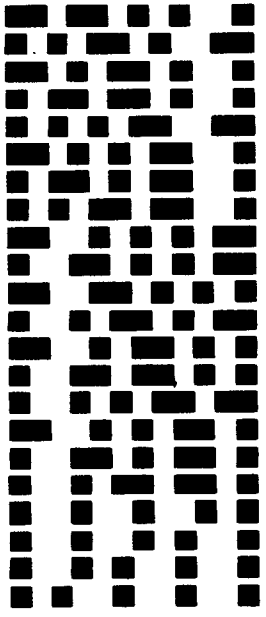
ENCODED CHARACTER	BINARY PATTERN B S B S B S B S B	CHARACTER SYMBOL	ENCODED CHARACTER	BINARY PATTERN B S B S B S B S B	CHARACTER SYMBOL
1	1 0 0 1 0 0 0 0 1		M	1 0 1 0 0 0 0 1 0	
2	0 0 1 1 0 0 0 0 1		N	0 0 0 0 1 0 0 1 1	
3	1 0 1 1 0 0 0 0 0		O	1 0 0 0 1 0 0 1 0	
4	0 0 0 1 1 0 0 0 1		P	0 0 1 0 1 0 0 1 0	
5	1 0 0 1 1 0 0 0 0		Q	0 0 0 0 0 0 1 1 1	
6	0 0 1 1 1 0 0 0 0		R	1 0 0 0 0 0 1 1 0	
7	0 0 0 1 0 0 1 0 1		S	0 0 1 0 0 0 1 1 0	
8	1 0 0 1 0 0 1 0 0		T	0 0 0 0 1 0 1 1 0	
9	0 0 1 1 0 0 1 0 0		U	1 1 0 0 0 0 0 0 1	
0	0 0 0 1 1 0 1 0 0		V	0 1 1 0 0 0 0 0 1	
A	1 0 0 0 0 1 0 0 1		W	1 1 1 0 0 0 0 0 0	
B	0 0 1 0 0 1 0 0 1		X	0 1 0 0 1 0 0 0 1	
C	1 0 1 0 0 1 0 0 0		Y	1 1 0 0 1 0 0 0 0	
D	0 0 0 0 1 1 0 0 1		Z	0 1 1 0 1 0 0 0 0	
E	1 0 0 0 1 1 0 0 0		-	0 1 0 0 0 0 1 0 1	
F	0 0 1 0 1 1 0 0 0		.	1 1 0 0 0 0 1 0 0	
G	0 0 0 0 0 1 1 0 1		SPACE	0 1 1 0 0 0 1 0 0	
H	1 0 0 0 0 1 1 0 0		*	0 1 0 0 1 0 1 0 0	
I	0 0 1 0 0 1 1 0 0		$	0 1 0 1 0 1 0 0 0	
J	0 0 0 0 1 1 1 0 0		/	0 1 0 1 0 0 0 1 0	
K	1 0 0 0 0 0 0 1 1		+	0 1 0 0 0 1 0 1 0	
L	0 0 1 0 0 0 0 1 1		%	0 0 0 1 0 1 0 1 0	

Fig 2 - Code 39 Code Structure

(1) Assume the message data to be encoded were:

A F P 1 1 2 8 8 3 Q E D 1 0 1 J

Referring to Table C, the respective character values become:

15,25,1,1,2,8,8,3,26,14,13,1,0,1,19

(2) The positional weights assigned become, respectively:

16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1

(3) Multiplying the value and weight for each character, the products become:

Data	Value (V)	Weight (W)	Product (VxW)
A	10	16	160
F	15	15	225
P	25	14	350
1	1	13	13
1	1	12	12
2	2	11	22
8	8	10	80
8	8	9	72
3	3	8	24
Q	26	7	182
E	14	6	84
D	13	5	65
1	1	4	4
0	0	3	0
1	1	2	2
J	19	1	19
			1314

(4) Division by 43 results in 30 with a remainder of 24.

(5) The remainder of 24 becomes the check character, and encoding per Table C yields a character of O.

(6) The final message to be bar coded becomes:

S/S A F P 1 1 2 8 8 3 Q E D 1 0 1 J O S/S

TABLE C
CODE 39 CHARACTER VALUES

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

C. Quiet Zone

2.14 The clear area immediately preceding and following the bar code should be at least 0.25 inch for optimum wand scanning. However, where application design considerations involve critical space limitations, a quiet zone of minimum 10 times the width of the narrow element, or 0.10 inch, whichever is greater, may be used. Such reductions adversely affect scanner first-read rates.

OPTICAL REQUIREMENTS

A. Reflectivity and Print Contrast Signal (PCS)

2.15 Scanners function on the variations of light reflected by the printed bars and the label surface during scanning. The performance of the scanner is therefore directly affected by the reflectance of these areas and the contrast between them. Many bar code scanners are designed to operate using infrared light, minimizing any spurious effects that may be contributed by ambient light. Thus the reflectance and contrast seen by the human eye may not be truly indicative of that detected by the scanner. Measurements of reflectance and PCS should employ instruments optically and spectrally designed for such purpose, eg, Macbeth Model PCM II.

(a) ***Measurement Conditions***: Reflectance is the percentage of incident light reflected by the surface under measurement. Label reflectance measurement of symbols to be scanned by infrared scanners are made under the following specific optical and spectral conditions:

(1) Radiant flux shall be incident to the surface at a 45 degree angle with reflected flux collected within a 60 degree cone, the central axis of which is perpendicular to the surface area being measured.

(2) The aperture diameter of the instrument shall be a maximum of 0.008 inch.

(3) Radiant and measured flux shall have an effective wavelength of 906 plus or minus 2 nanometers (nm) with a band width of 40 to 50 nm at the 50 percent relative response level.

(4) 100 percent reflectance level calibrated using a magnesium oxide or barium sulfate standard.

(5) Label specimen mounted on a surface having a reflectance of 10 percent maximum.

(b) ***Reflectivity***: The reflectance of the quiet zones shall be a minimum of 60 percent and that of the spaces between bars a minimum of 51 percent. The reflectance of the bars shall be a maximum of 11 percent.

(c) ***Print Contrast Signal***: PCS is measured using wide bars and spaces selected near the beginning, middle, and end of the bar code. The PCS is defined as:

$$PCS = \frac{Rs - Rb}{Rs}$$

where Rs = Reflectance of space between bars
Rb = Reflectance of the bar

The calculated PCS for any pair shall be a minimum of 0.78.

B. Spots and Voids

2.16 Ink spots or smears within spaces and/or voids or skips within bars may result in misinterpretation of bar/space widths, causing erroneous readings. Such defects that are sufficiently small as not to adversely affect scanning may be tolerated. The tolerance criteria used is that such spots or voids must be entirely contained within one quarter of a circle whose diameter is 80 percent of the nominal width of the narrow bar.

3. SCANNING CONSIDERATIONS

BAR CODE SYMBOL PLACEMENT

3.01 Apparatus and equipment design should allocate adequate space on external surfaces for mounting and scanning the bar code. The space required is a function of the scanner to be used. In general, noncontact scanners will require less unobstructed space around the symbol than that required for contact scanners.

LABEL CONSTRUCTION

3.02 The selection of label materials and construction should consider the following:

(a) Labels subject to frequent contact scanning or long life applications should make provision for durability. Such may include a protective laminate over the label surface. However, such laminate should be compatible with the scanner, eg, laminate thickness within the depth of field of the wand, or laminate spectral and/or specular properties suitable to the contact or remote scanner(s) being used.

(b) Label stock should demonstrate properties of durability, color stability during designed life, and opaqueness, to minimize any optical effects of mounting surface showing through the label during scanning.

(c) The adhesive used for sticking a label to a surface should be selected to ensure retention during label life, retain characteristics over anticipated environmental conditions, and not adversely affect the encoded information.

(d) Surface gloss of labels shall not be excessive.