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CEA Standard

Component Marking Standard

CEA-706-A

November 2004



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(From Project Number 2038, formulated under the cognizance of the CEA's **R9 Data Capture Committee**.)

Published by

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Technology & Standards Department
2500 Wilson Boulevard
Arlington, VA 22201

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1. Scope

This standard describes the requirements for using formatted two-dimensional machine-readable symbols for the marking of electronic components of first level assemblies.

Note: This standard is not intended to address product marking applications. (See CEA-802-A)

Note: Marking of reels, tubes, and trays containing components is subject to Product Package marking. (See CEA-624-A)

2. Purpose

The purpose of this standard is to establish a common structure for encoding data to be marked on electronic components to facilitate automation. This standard provides a means for components to be marked and read in a fixtured environment at any manufacturer's facility and be read by customers purchasing components for subsequent manufacturing operations.

Intended applications include, but are not limited to:

- component traceability
- component tracking
- automated manufacturing process control
- logistics
- inventory management
- robotic assembly
- configuration management
- automated inspection and quality control
- Computer-Aided Design (CAD) engineering and automated revision control
- anti-counterfeiting systems
- automated testing

3. Definitions

ANSI - The American National Standards Institute. A non-governmental organization responsible for the coordination of voluntary national (United States) standards.

Application Identifier (AI) - A specified string of characters that defines the general category or intended use of the data that follows. These identifiers are specified in the General EAN.UCC Specifications.

Cell - The smallest element of a two-dimensional matrix symbol.

Data Character - A letter, digit or other member of the American Standard Code for Information Interchange (ASCII) character set.

Symbol Character - A unique bar and/or space pattern, or a dark and light cell pattern, which is defined for a specific symbology.

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

Components - For the purposes of this document, electronic or electrical parts (e.g., bare printed circuit boards, integrated circuits, capacitors, diodes, electronic modules, switches, heat sinks, resistors, electronic/electrical connector, etc.) of a first level assembly.

Data Identifier (DI) - A specified character string that defines the specific intended use of the data that immediately follows. The identifier shall be an alphabetic character or an alphabetic character preceded by up to three numeric characters as defined by ANSI MH10.8.2, Data Application Identifier Standard and ISO/IEC 15418 Information technology -- EAN/UCC Application Identifiers and Fact Data Identifiers and Maintenance. A character (or set of characters) within a machine-readable symbol that defines the general category or specific use of the data that is encoded in the same machine-readable symbol.

First Level Assemblies - A manufactured electronic item (e.g., populated printed circuit board, plug-in or Personal Computer Memory Card International Association (PCMCIA) card) made up of components.

Human-Readable Interpretation - The letters, digits or other characters associated with specific symbol characters and printed along with the linear bar code or two-dimensional symbol.

Manufacturer - Actual producer or fabricator of a component or the supplier in a transaction if the supplier is the warrantor of the component.

Overhead Characters - Those characters included within a symbol that are not data characters, e.g., start, stop, error checking, concatenation, and field identifier characters.

Quiet Zone - Areas of high reflectance (spaces) surrounding the machine-readable symbol. Quiet zone requirements may be found in application and symbology specifications. Sometimes called the "Clear Area" or "Margin."

Structure - The order of data elements in a message.

Substrate - The material (paper, plastic, metal, etc.) upon which a symbol is marked.

Supplier - The trading partner in a transaction that provides the component (e.g., manufacturer, distributor, reseller, etc.)

Symbol - A machine-readable pattern comprised of a quiet zone, finder pattern, symbol characters (which include special function and error detection and/or correction characters) required by a particular symbology. See also 3.4.

Syntax - The way in which data is put together to form messages. Syntax also includes rules governing the use of appropriate identifiers, delimiters, separator character(s), and other non-data characters within the message. Syntax is the equivalent to grammar in spoken language.

4. References

American National Standards Institute (ANSI)

25 West 43rd Street
New York, NY 10036
+1 212.642.4900
www.ansi.org

- ANSI/MH10.8.2 Data Application Identifier Standard available from American National Standards Institute (ANSI)
- ANSI/MH10.8.3 – Transfer Data Syntax for High Capacity ADC Media

Uniform Code Council, Inc.

Princeton Pike Corporate Center
1009 Lenox Drive, Suite 202
Lawrenceville, NJ 08648
+1 609 620 0200
<http://www.uc-council.org/>

- General EAN.UCC Specifications

International Organization for Standardization (ISO)

1, rue de Varembe, Case Postale 56
CH-1211 Geneva 20, Switzerland
+41 22.749.01.11
www.ISO.org

International Electrotechnical Commission (IEC)

3 rue de Varembe, P. O. Box 131
CH-1211 Geneva 20, Switzerland
+ 41 22.919.02.11

- ISO/IEC 646 Information Processing - ISO 7-Bit Coded Character Set for Information Interchange
- ISO 3166-1 - Codes for the representation of names of countries and their subdivisions -- Part 1: Country codes
-
- ISO/IEC 15415 – Information technology – Automatic identification and data capture techniques – Bar code print quality test specification – Two dimensional symbols
- ISO/IEC 15418 - Information technology -- EAN/UCC Application Identifiers and Fact Data Identifiers and Maintenance
- ISO/IEC 16022 - Information technology -- International symbology specification – Data Matrix

5. Data Content

5.1 Field Length

Field length is the number of data characters in a data field. The character count of data characters is exclusive of overhead characters.

5.2 Mandatory Data

The Mandatory Data shall be represented by a maximum of 50 user data characters (see 5.2.5.1). It is the recommendation of this standard that Data Identifiers be used to identify data fields. Application Identifiers may be used only with mutual agreement between trading partners. The Manufacturer Identification (see 5.2.1), Item Identification (see 5.2.2) and Traceability (see 5.2.3) data shall be included in the symbol.

5.2.1 Manufacturer Identification

Each item shall have the manufacturer identified. Acceptable Manufacturer IDs include the EAN.UCC Company Prefix, Data Universal Numbering System (D-U-N-S®) code, Commercial And Government Entity (CAGE) code or as agreed to between the trading partners. Other Electronic Identification (EID) registration authorities may be used upon agreement of the trading partners.

5.2.1.1 Manufacturer Identification Data Identifier

The Manufacturer ID shall be identified with a data identifier indicating the type of enterprise ID as follows. When possible, Data Identifiers identifying the registration authority should be used.

<u>Enterprise ID type</u>	<u>Data Identifier</u>	<u>Sample</u>	<u>Notes</u>
EAN.UCC Company Prefix	3V	3V07164181	A 0 (zero) is prefixed to the company prefix; 7164181 is the company prefix in this example
D-U-N-S Number	12V	12V436929531	The D-U-N-S number is 436929531
CAGE Code	17V	17V12592	The CAGE code is 12592
Customer's Supplier ID	V	V23NPNSA2	23NPNSA2 is the supplier ID assigned by the customer; no EID registration authority is implied.

5.2.2 Item Identification

The maximum length of the *Item Identification* shall be 25 data characters. Item identification codes may be concatenated with the manufacturer identification to produce a unique item identification.

The 14-digit EAN/UCC-14 is a fixed length numeric example of such unique identification.

5.2.2.1 Item Identification Data Identifier

The Data Identifier “1P” shall precede *Manufacturer Item Identification* data. The Data Identifier “P” shall precede Customer Item Identification data.

When using EAN.UCC item identification and data identifier, the data identifier 3P shall precede the EAN.UCC-13 or EAN.UCC-12 combined manufacturer and item identifier. The EAN.UCC-12 shall be prefixed with one zero for a total data length of 13 to be consistent with EAN.UCC coexistence recommendations.

Note that the EAN.UCC identification scheme does not allow the user to parse an EAN.UCC number to determine the manufacturer. As a consequence the manufacturer ID must also be marked per 5.2.1 in addition to the EAN.UCC number.

5.2.3 Traceability Information

Traceability information is assigned by the manufacturer or supplier. *Traceability* information may incorporate the following data fields: lot or batch number, manufacturing location, date of manufacture, serial number, revision level, country of origin, etc. These fields may be encoded as a single Traceability data element. The data element consists of the appropriate Data Identifier and its associated data.

The maximum length of Traceability information shall be 18 characters, which excludes the associated Data Identifier. If more Traceability data is required, then it may be included in additional data fields (see 5.2.4).

5.2.3.1 Traceability Code Data Identifier

The appropriate Data Identifier shall precede the Traceability data. See Annex A for a listing of commonly used Data Identifiers.

5.2.4 Additional Data Fields

Additional data fields consistent with ANSI MH10.8.3 may be included in the symbol as long as the symbol size does not exceed 7 mm by 7 mm. See Annex A for commonly used Data Identifiers and Annex C for Data Matrix symbol sizes.

Separate symbols may be added, at the discretion of the manufacturer, when additional data is required. Placement of any additional symbol shall not interfere with the requirements of 6.2.6 Symbol and Text Orientation for primary symbol placement.

5.2.5 Data Field Syntax

The message shall be encoded using the ANSI MH10.8.3 format. The message Header, the first 7 characters " $[] >^R_S 06^G_S$ ", and the Trailer, the last 2 characters " $^R_S E O_T$ ", are fixed for this application, in accordance with the ANSI MH10.8.3 standard, when Data Identifiers are used within the message.

When combining data fields within a two dimensional symbol, the " G_S " (ASCII/ISO 646 Decimal "29", Hex "1D") character shall be used with the appropriate Data Identifier to identify each of the combined fields.

5.2.5.1 Example of Maximum Length Message

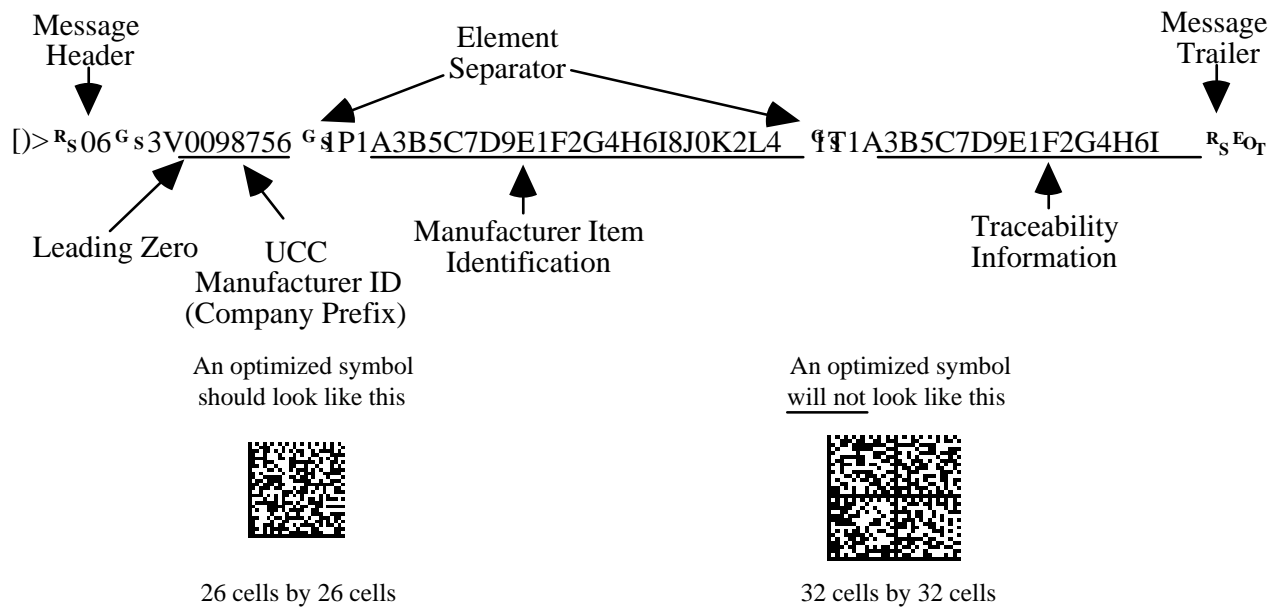
A symbol comprising the mandatory fields, each at their maximum length contains:

- 53 user data characters,
 - 10-Character Manufacturer Identifier (maximum length of EAN.UCC Company Number), 25-Character Item Identification, and 18-Character Traceability Code
- 6 identifier characters,
- 2 separator characters, and
- 9 Message Header and Trailer characters

for a total of 70 characters.

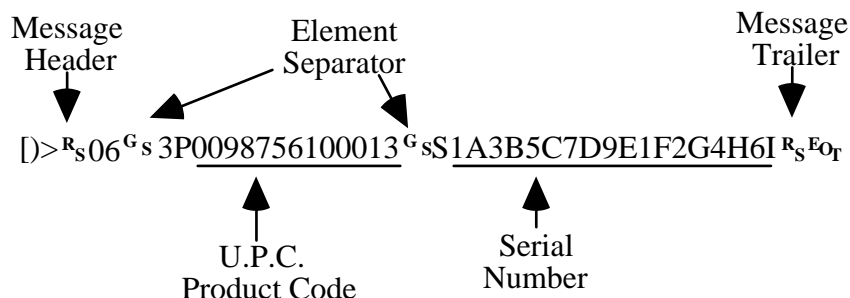
When using optimal Data Matrix compaction features, a symbol containing the three mandatory fields, each of maximum length, will fit in a 3 mm by 3 mm area when using 0.102 mm (0.004 inch) cells. See Table 1. For details of optimal compaction see ISO/IEC 16022.

This example is comprised of Data Identifiers, other overhead characters, and maximum length mandatory fields (the 7-digit Manufacturer Identification, a 25 character maximum length Item Identification, and an 18 character maximum length Traceability Identification.)



5.2.5.2 Example of Reduced Length Message

The total message length, using the ANSI MH10.8.3 format, can be reduced by using a Universal Product Code (U.P.C.) product code as the Item ID and a Serial Number as the Traceability identification. The total message length using this format could contain as many 44 characters, assuming that a maximum length (18 character) Traceability Identification is used.



An optimized symbol should look like this



22 cells by 22 cells

GRAPHIC ABOVE NOT ACTUAL SIZE

Where the space available to mark a component is restricted, the number of characters that can be encoded in the item identification or traceability information will be reduced.

6. Symbology Requirements

The symbology specified by this standard is Data Matrix ECC200, as defined by the ISO/IEC 16022.

6.1 Level of Error Correction

The error correction level shall be ECC200.

6.2 Physical Characteristics of the Symbol

This section defines the marking requirements for the symbol.

6.2.1 Symbol Size

The maximum symbol size shall be 7 mm by 7 mm. The reason for this requirement is to establish a known field of view for reading the mark. No minimum symbol size is specified. However, a minimum cell size is specified in 6.2.2.

It is recommended that the user implement their system using the largest cell size that will fit in the available area, up to the maximum dimensions shown in this table. This will allow for the best possible scanner performance. Cell sizes below 0.150 mm (0.006 inch) are not recommended because these symbols cause a reduced depth of field. Cell sizes below 0.150 mm (0.006 inch) may only be appropriate for use when the marking area on a component will not permit the use of 0.150 mm (0.006 inch) or greater cell sizes. The particular symbol size that is realized will depend on the amount and type of data encoded.

Table 1 - Symbol Size versus Cell Size Based on Mandatory Fields at Maximum Length
(size includes quiet zones)

	Cell Size				
	0.102 mm (0.004 inch)	0.150 mm (0.006 inch)	0.175 mm (0.007 inch)	0.200 mm (0.008 inch)	0.250 mm (0.010 inch)
Symbol Size	2.9 x 2.9 mm	4.2 x 4.2 mm	4.9 x 4.9 mm	5.6 x 5.6 mm	7.0 x 7.0 mm

6.2.2 Feature Size Cell Width and Height

The feature size is determined by many factors including marking area available, surface type, environment and reading device(s) used. The minimum open system width of the cell shall be 0.102 mm (0.004 inch). The minimum open system height of the cell shall be 0.102 mm (0.004 inch) in a non clean room environment.

The minimum symbol size to encode the maximum 50 user data character message shall be 2.9 mm by 2.9 mm, including quiet zones, based on a cell size of 0.102 mm (0.004 inch) and an error correction level of ECC200.

6.2.3 Quiet Zones

The quiet zones are specified as a minimum of one (1) cell width on all four sides of the mark area. The quiet zone may be the space contiguous to the edge(s) of the mark where the imaged area abuts the physical edge or edges of the item being imaged. It is not the intent of this standard to require additional quiet zone beyond the minimum required by the symbology specification.

6.2.4 Surface Topography

In order to achieve an acceptable print quality with a cell width/height of 0.102 mm (0.004 inch), it may be necessary to specify a particular component surface finish and/or geometry of lighting conditions. Molded component surface finish should be Charmille VDI 3400 Scale of 18-24 or EDM finish of .8-1.6 micrometers on RA scale.

6.2.5 Substrate Properties

Substrates may be various colors and marks on these substrates may be light or dark. The ISO/IEC 16022 Standard will provide guidance for marking substrates that are dark or light.

6.2.6 Symbol and Text Orientation

6.2.6.1 Symbol Orientation And Placement

The symbol shall be oriented such that the intersection of the two solid lines of the symbol's finder pattern points to the lower left of the component. The bottom solid line of the symbol should be parallel to the lines of text. The symbol should be visible on the finished assembly. When this surface is covered, e.g., with a heat sink, the symbol should be placed on the pin side.

The symbol should be placed at the center of the left side of the component as determined by the orientation of the human-readable text for reading. The human-readable text should be placed to the right of the symbol. See Figures 1 through 5, for examples of symbol placement.

When component orientation is not critical or related to component functionality, the symbol shall be located and oriented as mutually agreed to between trading partners.

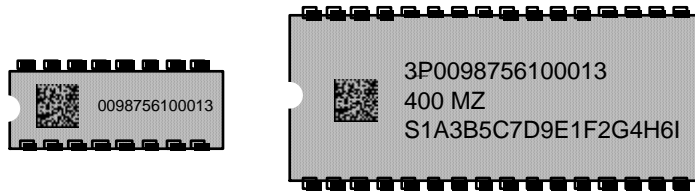


Figure 1 - Dual In-line Package Marking Example

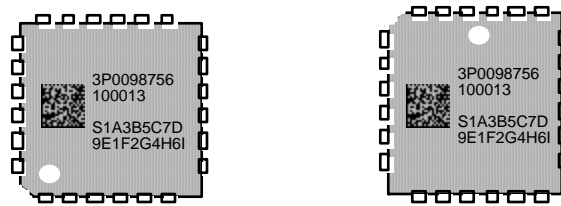
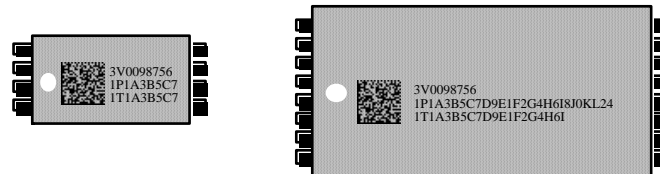
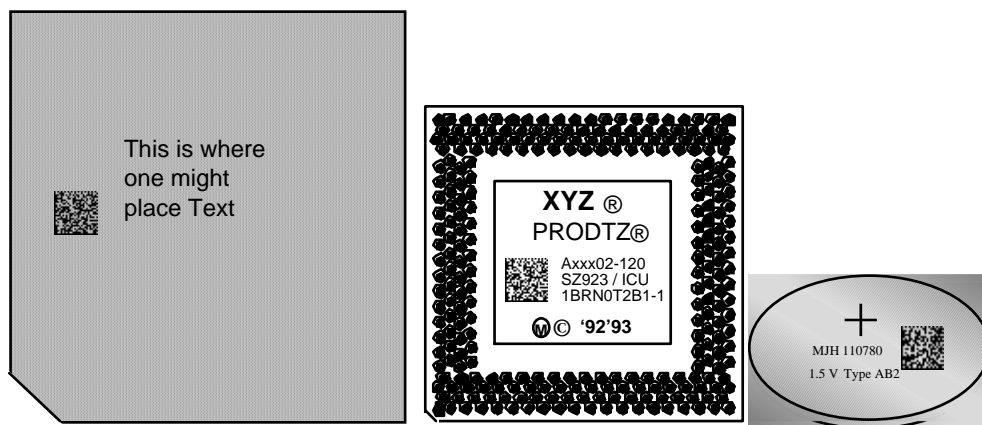


Figure 2 - Quad Flat Pack (QFP) Marking Example





6.2.6.2 Text

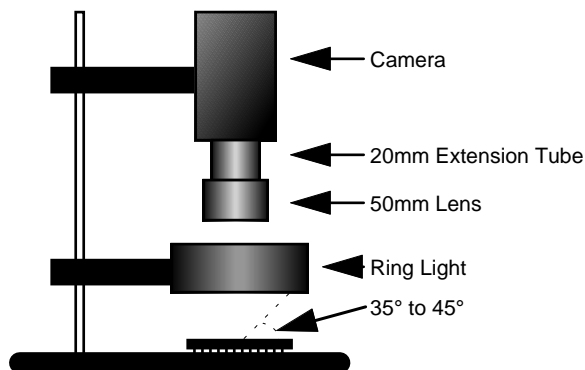
This standard does not address the marking of human-readable interpretation of symbol data or text. This standard does not supersede or replace any applicable safety or regulatory marking or labeling requirements. This standard is to be applied in addition to any other mandated labeling requirements.

6.3 Print Quality

6.3.1 Test Set-Up Measurement Methodology

The printed or marked symbol to be measured shall be illuminated by a white light source such as a Stocker and Yale 9-Series Circular Illuminator (70 mm (2.9 inch) diameter fluorescent ring light) or equivalent. The light source shall be mounted at a height to provide a 35 to 45 degree angle of incidence, relative to the symbol surface.

The distance from the bottom of the fluorescent bulb to the marked surface should be approximately 24 mm (40 degree angle of incidence). Consistent measurements have been achieved using an NEC Model TI324A CCD camera having a shutter speed of 1/2000th of a second, a 20 mm lens extension tube, and a 50 mm lens set at an f-stop of f.8. The image shall be in focus. The distance from the bottom of the lens to the top of the component (image plane) is recommended to be approximately 160 mm (6.25 inches).



Print Quality Equipment Set-Up

6.3.2 Test Set-Up Calibration of Measurement Systems

Calculate the reference reflectivity per ISO/IEC 15416, where a working standard symbol shall be obtained by 1) buying a pre-measured symbol or 2) measuring a diffuse white and carbon black symbol with a MacBeth reflectometer at 680 nm. Determine the Symbol Contrast (SC) of the working standard symbol. The working standard symbol shall be an "A" quality symbol according to ISO/IEC 15415. Verify that the measured gray level of the working standard symbol sample is between 150 and 200, out of 256. Ambient light levels shall be controlled in order not to have any influence on the measurement results.

6.3.3 Print Quality of the Symbol

The Print Quality shall be measured per ISO/IEC 15415. Note that the additional reflectance check per clause 7.6 of ISO/IEC 15415 shall be performed, since the risk of excessively high or low reflectance values in the extended area is significant for this application.

The symbol grade shall be reported per clause 5.4 of ISO/IEC 15415 as *grade/aperture/light/angle*. The minimum print quality requirement shall be 1.5*/03/W/40. The asterisk following the value for *grade* indicates that the surroundings of the symbol contain extremes of reflectance that may interfere with reading, "W" is for white light (see clause 6.3.1) and the *angle* shall be 40 ±5 degrees corresponding to the actual set-up used per clause 6.3.1. It is recommended that every attempt be made to achieve a minimum print quality grade of 2.5*/03/W/40.

6.4 Encryption

Encryption shall not be used for mandatory data fields.

6.5 Character Set

The character set shall be upper case alphabetic characters, numeric digits, and the eight characters (-, ., Space, \$, /, +, *, and %), as well as the recommended field separators, record separators, segment terminators and compliance indicators. A table of these characters and their hexadecimal and decimal equivalent is included as Annex B.

7. Reader Considerations

7.1 Fixturing

Fixturing is an environment where a mechanical system positions both the component and the reading device. Due to the small cell sizes possible in this application, small Depth of Field (less than 2.5 mm) will be common. Reading stations will need to be designed to read at a relatively precise setting. One method that could be used is to fixture both the reader and component during the reading process.

7.2 Focus

In order to be able to read the range of different cell sizes with a single reader configuration, it is recommended that the optimum focus of the read system be determined with a symbol utilizing the minimum cell size (0.102 mm).

ANNEX A - Commonly Used Identifiers

(This Annex is Informative and Not Part of This Standard)

The Table below provides a listing on commonly used Data Identifiers, the appropriate Identifier Description, and associated Application Identifiers. Data Identifiers are defined in the General EAN.UCC specifications.

Data Identifier	Identifier Description	Application Identifier
6D	ISO format YYYYMMDD immediately followed by an ANSI X12.3 Data Element Number 374 Qualifier providing a code specifying type of date (e.g., manufacture date “094”)	No Equivalent
5D	ISO format YYMMDD immediately followed by an ANSI X12.3 Data Element Number 374 Qualifier providing a code specifying type of date (e.g., manufacture date “094”)	11 (Production Date)
4L	Country of Origin, two-character ISO 3166-1 country code	904L
P	Item Identification Code assigned by Customer	241
1P	Item Identification Code assigned by Supplier	01
2P	Code assigned to specify the revision level for an Item (e.g., engineering change level, edition, or revision)	240
3P	Combined EAN.UCC Manufacturer identification code/item code. EAN.UCC-12 codes shall be preceded by a 0 (zero).	01
S	Serial number or code assigned by the Supplier to an entity for its lifetime, (e.g., computer serial number, traceability number, contract tool identification)	21
1S	Additional code assigned by the Supplier to an entity for its lifetime (e.g., traceability number, computer serial number)	250
1T	Traceability Number assigned by the Supplier to identify/trace a unique group of entities, (e.g., lot, batch, heat)	10
V	Supplier Code assigned by Customer	90V
1V	Supplier Code assigned by Supplier	901V
3V	6-digit Company Code as assigned by the Uniform Code Council (UCC) preceded by the digit zero (0)	903V (776 pending assignment)
12V	D-U-N-S number identifying manufacturer	9012V
17V	U.S. DoD CAGE Number	9017V

ANNEX B

Subset of ASCII/ISO 646 (Table of Hexadecimal and Decimal Values)

HEX	DEC	ASCII / ISO 646	HEX	DEC	ASCII / ISO 646	HEX	DEC	ASCII / ISO 646
00	00	NUL	30	48	0	60	96	'
01	01	SOH	31	49	1	61	97	a
02	02	STX	32	50	2	62	98	b
03	03	ETX	33	51	3	63	99	c
04	04	EOT	34	52	4	64	100	d
05	05	ENQ	35	53	5	65	101	e
06	06	ACK	36	54	6	66	102	f
07	07	BEL	37	55	7	67	103	g
08	08	BS	38	56	8	68	104	h
09	09	HT	39	57	9	69	105	i
0A	10	LF	3A	58	:	6A	106	j
0B	11	VT	3B	59	;	6B	107	k
0C	12	FF	3C	60	<	6C	108	l
0D	13	CR	3D	61	=	6D	109	m
0E	14	SO	3E	62	>	6E	110	n
0F	15	SI	3F	63	?	6F	111	o
10	16	DLE	40	64	@	70	112	p
11	17	DC1	41	65	A	71	113	q
12	18	DC2	42	66	B	72	114	r
13	19	DC3	43	67	C	73	115	s
14	20	DC4	44	68	D	74	116	t
15	21	NAK	45	69	E	75	117	u
16	22	SYN	46	70	F	76	118	v
17	23	ETB	47	71	G	77	119	w
18	24	CAN	48	72	H	78	120	x
19	25	EM	49	73	I	79	121	y
1A	26	SUB	4A	74	J	7A	122	z
1B	27	ESC	4B	75	K	7B	123	{
1C	28	FS	4C	76	L	7C	124	
1D	29	GS	4D	77	M	7D	125	}
1E	30	RS	4E	78	N	7E	126	~
1F	31	US	4F	79	O	7F	127	DEL
20	32	SP	50	80	P			
21	33	!	51	81	Q			
22	34	"	52	82	R			
23	35	#	53	83	S			
24	36	\$	54	84	T			
25	37	%	55	85	U			
26	38	&	56	86	V			
27	39	'	57	87	W			
28	40	(58	88	X			
29	41)	59	89	Y			
2A	42	*	5A	90	Z			
2B	43	+	5B	91	[
2C	44	,	5C	92	\			
2D	45	-	5D	93]			
2E	46	.	5E	94	^			
2F	47	/	5F	95	_			

Values shown in **BOLD** are specifically supported by this standard.

ANNEX C

Data Matrix ECC200 Dimensions

Table C-1 - Data Matrix ECC200 Dimensions

Symbol Size (in x)		Data Region		Total Codewords		Reed-Solomon Block			Inter- leaved Blocks	Numeric Capacity	Data Alphanumeric Capacity	8-bit byte Capacity	Error Correction Overhead %
Row	Col	Size	Number	Data	Error	Data	Error	Total					
10	10	8x8	1	3	5	3	5	8	1	6	3	1	62.5
12	12	10x10	1	5	7	5	7	12	1	10	6	3	58.3
14	14	12x12	1	8	10	8	10	18	1	16	10	6	55.6
16	16	14x14	1	12	12	12	12	24	1	24	16	10	50.0
18	18	16x16	1	18	14	18	14	32	1	36	25	16	43.8
20	20	18x18	1	22	18	22	18	40	1	44	31	20	45.0
22	22	20x20	1	30	20	30	20	50	1	60	43	28	40.0
24	24	22x22	1	36	24	36	24	60	1	72	52	34	40.0
26	26	24x24	1	44	28	44	28	72	1	88	64	42	38.9
32	32	14x14	4	62	36	62	36	98	1	124	91	60	36.7
36	36	16x16	4	86	42	86	42	128	1	172	127	84	32.8
40	40	18x18	4	114	48	114	48	162	1	228	169	112	29.6
44	44	20x20	4	144	56	144	56	200	1	288	214	142	28.0
48	48	22x22	4	174	68	174	68	242	1	348	259	172	28.1
52	52	24x24	4	204	84	102	42	144	2	408	304	202	29.2
64	64	14x14	16	280	112	140	56	196	2	560	418	278	28.6
72	72	16x16	16	368	144	92	36	128	4	736	550	366	28.1
80	80	18x18	16	456	192	114	48	162	4	912	682	454	29.6
88	88	20x20	16	576	224	144	56	200	4	1152	862	574	28.0
96	96	22x22	16	696	272	174	68	242	4	1392	1042	694	28.1
104	104	24x24	16	816	336	136	56	192	6	1632	1222	814	29.2
120	120	18x18	36	1050	408	175	68	243	6	2100	1573	1048	28.0
132	132	20x20	36	1304	496	163	62	225	8	2608	1954	1302	27.6

Table C-2 - Approximate Number of Characters (User Data, Separators, and Identifiers)
in Selected Data Matrix Symbol Configurations

Symbol Size	Cell Size				
	0.102 mm (0.004 inch)	0.150 mm (0.006 inch)	0.175 mm (0.007 inch)	0.200 mm (0.008 inch)	0.250 mm (0.010 inch)
2 mm	22	4	N/A	N/A	N/A
3 mm	58	22	8	4	1
4 mm	116	46	27	22	8
5 mm	196	58	58	38	22
6 mm	278	116	82	58	38
7 mm	383	196	116	82	58

CEA Document Improvement Proposal

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