Interleave 2/5

Specification for Barcode Symbology

1.0 Introduction

USS-I 2/5 (nee Interleaved 2-of-5) is a bar code symbology with a numeric character set and different start and stop patterns. The name Interleaved 2-of-5 is derived from the method used to encode pairs of characters. In the symbol, two characters are paired together using bars to represent the first character and spaces to represent the second. USS-I 2/5's characteristics are summarized in Table 1.

Encodable Character Set—Numeric
Code Type—Continuous
Symbol Length—Fixed (1)
Bidirectional Decoding?—Yes
Number Of Required Check Characters—None
Character Self-Checking—Yes
Smallest Nominal Element—0.0075 inch (0.191 mm)
Maximum Data Character Density—
18.0 Numeric Char./inch
(7.1 Numeric Char./cm)
Non-Data Overhead—1.1 Character
Option—Check Character
Additional Feature—Unique Start and Stop Patterns

(1) USS-I 2/5 permits encodation of any length numeric field having an even number of digits. However, in a specific reader application, the symbols must have a fixed length.

Table 1
Characteristics of USS-I 2/5

2.0 Symbol Description

2.1 General Characteristics

A complete USS-I 2/5 symbol for a number consists of bars or spaces for each character pair enclosed by the special start and stop patterns and quiet zones. For the character set 0 through 9, each character has two wide elements and three narrow elements. The five character elements are represented by bars for the more significant digit of the pair. The character code is derived from a pseudo-binary coded decimal format in which any decimal digit is represented by five binary positions, four weighted bits plus a parity bit, in which only two of the five bits are one. A translation of binary ones and zeroes to respective wide and narrow bar code elements results in two of five elements being wide; this gives rise to the name of the code.

The four-element start pattern and three-element stop pattern bracket the coded numeric data and permit bidirectional decoding of the symbol.

2.2 Data Character Encodation

Each symbol is formed from a series of one or more character pairs. Each pair is coded into a series of five bars and five spaces with the bars representing the code for the more significant digit of the pair while the spaces represent the code for the less significant digit. The element pattern for a digit is derived from the weighted position codes listed in Table 2. Reading from left to right the five element positions are weighted according to a 1, 2, 4, 7 and parity value. Except for the zero digit, the sum of the weighted numeric position yields the value of the coded digit. The parity bit is added when necessary to give all codes exactly two non-zero weights. The associated bar code elements are narrow for zero weights and wide for the unit weights.

2.2.1 Even Character Count Requirement

Since USS-I 2/5 symbols are created from character pairs, the number to be coded must have an even number of digits. Should a number containing an odd number of digits have to be encoded, then a leading zero must be added to produce an even number of digits. For example, the number 367 must be expanded to 0367.

2.2.2 Character Pairing

The number to be encoded is first grouped into pairs of adjacent digits proceeding from the most significant to the least significant digit. For example:

0367 yields 03,67
1265 yields 12,65

2.2.3 Encodation of Character Pairs

The numeric data of the bar code is formed by placing the symbols for each character pair adjacent to one another with the codes for the most significant character pairs on the left. In each pair of digits the more significant digit is encoded in the bars and the less significant digit is encoded in the spaces. Examples:

Original Number	Paired Numbers
0367	03,67

In the pair of "03", "0" is represented by the bars and "3" is represented by the spaces.

In the pair of "67", "6" is represented by bars and "7" is represented by spaces.

The binary values for each character are shown in Table 2. Figure 1 illustrates the two character pair symbols placed adjacent to one another representing the numeric data of the code.

Wide bars and spaces = BINARY 1
Narrow bars and spaces = BINARY 0
Each data character contains 5 binary elements; 2 of the 5 are binary 1's.

Data Character	Weighted Position 1	2	4	7	P
0 =	0	0	1	1	0
1 =	1	0	0	0	1
2 =	0	1	0	0	1
3 =	1	1	0	0	0
4 =	0	0	1	0	1
5 =	1	0	1	0	0
6 =	0	1	1	0	0
7 =	0	0	0	1	1
8 =	1	0	0	1	0
9 =	0	1	0	1	0

Table 2
Data Character Set

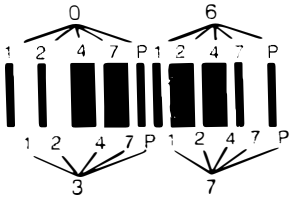

Figure 1

2.3 Start and Stop Pattern

Special start and stop patterns are necessary to identify the leading and trailing ends of the bar code symbol. The start pattern consists of four narrow elements beginning with a bar. The stop pattern is a wide bar followed by two narrow elements. The start pattern is positioned at the normal left end of the data symbols adjacent to the most significant digit. The stop pattern is positioned at the normal right end of the data symbols adjacent to the least significant digit.

Figure 2 illustrates the start and stop patterns and their relationship to the encoded data characters.

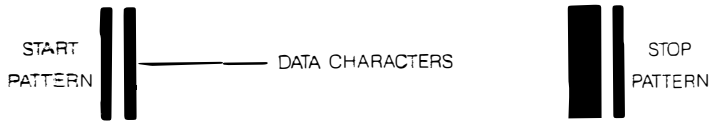

Figure 2

2.4 Quiet Zone

The quiet zone is an area that is free and clear of all printing preceding the start pattern and following the stop pattern.

Figure 3 illustrates a complete bar code for the number 0123 showing the necessary quiet zone.

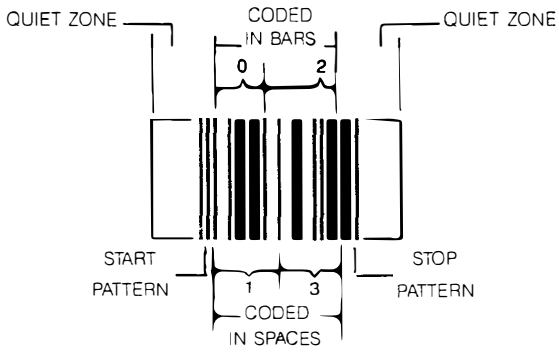

Figure 3

2.5 Check Digit

No check character is required for USS-I 2/5 but Appendix C describes a recommended calculation formula and data format when a check digit is desired.

2.6 Fixed Symbol Length

In a specific implementation using the USS-I 2/5 symbology the number of characters in all symbols shall be the same and the reading equipment shall be set for the selected length.

2.7 Transmitted Data

The decoded data derived from USS-I 2/5 should include all numeric data characters encoded in the field. Start and stop characters should not be included in the output of the reader data.

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 width of a narrow element.

3.2 Physical Dimensions

The nominal narrow element width for the USS-I 2/5 symbology has a minimum standard value of 0.0075 inches (0.191 mm). Appendix F discusses applications of symbologies with elements smaller than this standard.

For general application, the minimum bar height should be 0.25 inches (6.35 mm) or 15 percent of the bar code symbol length, whichever is greater.

The minimum quiet zone width is ten times the X dimension or 0.10 inch (2.54 mm), whichever is greater. For optimum hand scanning, the quiet zone should be at least 0.25 inches (6.35 mm).

Wide element widths must be in the range 2.0X to 3.0X for X dimensions greater than or equal to 0.020 inches, (0.508 mm). If the X dimension is less than 0.020 inches (0.508 mm), then the wide element width must be in the range 2.2X to 3.0X. The X dimension and the ratio of wide to narrow elements, N, must be constant within a symbol.

3.3 Minimum Symbol Length

The length, L, of a typical USS-I 2/5 symbol including quiet zones can be calculated from the following expression:

$$L = (P(4N+6) + 6 + N)X + 2Q$$

where:

P = number of character pairs
N = wide to narrow element ratio
X = the width of a narrow element
Q = width of the quiet zone

3.4 Dimension 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.

The recommended printing tolerances presented below represent the maximum tolerances on element width which are deemed acceptable for USS-I 2/5.

The defining equation for printing tolerances is given as follows:

$$t = \pm \frac{(18N-21)}{80} X$$

where:

N = the wide to narrow ratio
X = the narrow element width.

Table 3 lists the tolerance values for some common nominal dimensions.

Nominal Width of Narrow Elements in inches (mm)	Wide to Narrow Ratio, "N"	Density Char/In	Element Width Tolerances, "t" in inches (mm)
0.0075 (0.191)	2.2	18.0	±0.0017 (0.044)
0.0200 (0.508)	2.0	7.14	±0.0038 (0.095)
0.030 (0.762)	2.5	4.17	±0.0090 (0.229)
0.040 (1.02)	3.0	2.78	±0.0165 (0.419)

Table 3

Figure 4 shows plots of printing tolerances as a function of narrow bar widths for selected ratios, N.

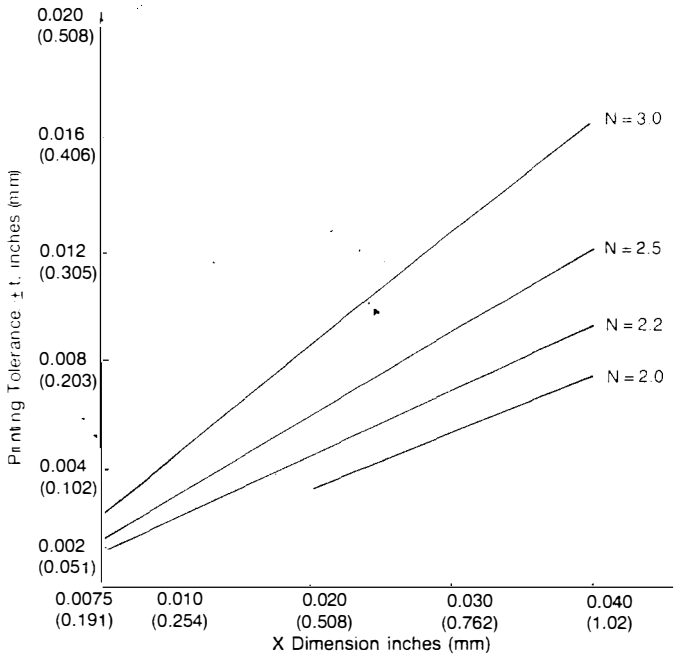

Figure 4. USS I 2/5 Dimensional Tolerances

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 discernable difference in reflectance exists between spaces and bars. This difference must be at least 37.5 percentage points for symbols with an X dimension of less than 40 mils (1.02 mm) and at least 20 percentage points for symbols with an X dimension of 40 mils (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 ade-

quately opaque. Reflectance variation within 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 specification 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 ±5 percent and having a half-power band width no greater than 120 nanometres (in which there are no secondary peaks). Among possible source-filter-photodetector combinations which can be used are those employing a He-Ne laser, appropriate red LED's or alternatively the CIE Source A illuminant (incandescent source) along with an S-4 response photodetector and a Wratten 26 red filter.

Appendix F includes a discussion of systems which are designed to operate in spectral bands other than the 633 nanometre 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 at 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 of the stated specifications.

4.3.2 Reflectance Measurements

Figure 5 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 5a 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 between a bar and space as defined in Section 3.1 above. A plot of the reflectance measurements is shown in Figure 5b 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), the maximum bar reflectance R_B (MAX), and the minimum bar reflectance R_B (MIN), obtained over all samples. On the right are indicated the ranges of reflectance $\triangle R_E$ obtained from a typical space and a typical bar element.

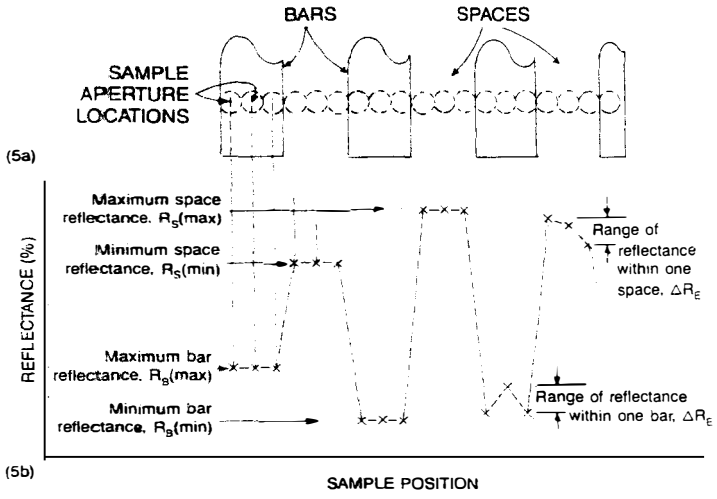

Figure 5. Bar Code Reflectance Measurements

4.4 Reflectance Specifications

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

4.4.1 Maximum Bar Reflectance (R_B)

R_B (MAX) < 30 percent

4.4.2 Minimum Space Reflectance (R_S)

R_S (MIN) > 25 percent

4.4.3 Minimum Bar-Space Reflectance Difference, MRD

The difference in reflectivity between the lightest bar and the darkest space is called MRD (Minimum Reflectance Difference). In other words, MRD = R_S(MIN) – R_B(MAX). The minimum value of MRD is:

MRD ≥ 37.5 percent for X < 0.040 inches (1.02 mm)
MRD ≥ 20 percent for X ≥ 0.040 inches (1.02 mm)

The special provisions for symbols with X ≥ .040 inches (1.02 mm) have been made in order to accommodate the printing of lower density labels on darker backgrounds.

4.4.4 Element Uniformity

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

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

ΔR_E (MAX) across one element ≤ 0.25 MRD

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

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

ΔR_S (MAX) = R_S (MAX) – R_S (MIN) ≤ 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) ≤ 0.5 MRD

Appendix A

AIM Glossary of Terms

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

Alphanumeric—The character set which contains letters, numbers and usually other characters such as punctuation marks.

Aperture—The opening in an optical system defined by a lens or 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.

A.N.S.I.—The American National Standards Institute—nee United States of America Standards Institute (USASI)—is a non-governmental organization responsible for the development of manufacturing standards.

Background—The lighter portion of a bar code symbol, including the quiet zones.

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

Bar Code—An array of parallel rectangular bars and spaces that together represent data elements or characters in a particular symbology. The bars and spaces are arranged in a predetermined pattern following unambiguous rules defined by the symbology, e.g. USS-39.

Bar Code Character—A single group of bars and spaces which represent an individual number, letter, punctuation mark or other symbol.

Bar Code Symbol—See Symbol

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

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

Bar Height—The dimension of a bar measured perpendicular to the bar width.

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.

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

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.

Character—1. A single group of bars and spaces which represent an individual number, letter, punctuation mark or other symbol. 2. A graphic shape representing a letter, numeral or symbol. 3. A letter, digit, or other symbol that is used as part of the organization, control, or representation of data.

Character Set—Those characters available for encodation in a particular bar code symbology.

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

Code—A set of unambiguous rules specifying the way in which data may be represented. (See "Bar Code".)

Continuous Code—A bar code symbol 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.

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

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

EAN—European Article Numbering System, the international standard bar code for retail food packages.

Element—A single bar or space.

Font—A specific size and style of printer's type.

Helium Neon Laser—The type of laser commonly used in bar code scanners. It emits coherent red light at a wavelength of 633 nm.

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

LED—Light emitting diode. A semiconductor that produces light at a frequency determined by its chemical composition. The light source commonly used in wand type readers.

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 unit of measure in a bar code.

Nanometre—A unit of measure used to define the wavelength of light. Equal to 10^{-9} metre.

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

Non-Read—The absence of data at the reader's output after an attempted scan due to no code, defective code, reader failure or operator error.

Numeric—A character set that includes only numbers.

Opacity—The 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 the symbol's scan path. Two possible orientations are horizontal with vertical bars and spaces (picket fence) and vertical with horizontal bars and spaces (ladder).

Overhead—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.
Quiet Zone—A clear space, containing no dark marks, which precedes the start character of a symbol and follows the stop character.
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.
Resolution—The narrowest element dimension which can be distinguished by a particular reading device or printed with a particular device or method.
Self-Checking—A bar code or symbol using a checking algorithm which can be independently applied to each character to guard against undetected errors.
Show-Through—The generally undesirable property of a substrate that permits underlying markings to be seen.
Space—The lighter element of a bar code usually formed by the background between bars.
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.
Spots—The undesirable presence of ink or dirt in a space.
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. 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.
Substrate—The surface on which a bar code symbol is printed.
Symbol—A combination of characters including start/stop characters, quiet zones, data characters, and check characters required by a particular symbology, which form a complete, scannable entity.
Symbol Length—The distance between the outside edges of the quiet zones.
UPC (Universal Product Code)—The standard bar code symbol for retail food packages in the United States.
USS—Uniform Symbology Specification of which this complete document is one. USS is used in the most recent of AIM symbology specifications.
Void(s)—The undesirable absence of ink in a bar.

Appendix B

Reference Decode Algorithm for USS-I 2/5

The allowable symbol printing tolerances for USS-I 2/5 are predicated on the use of a favorable error resistant decoding algorithm. An example of such an algorithm is briefly described below:

1. Confirm presence of a leading quiet zone.
2. Confirm presence of the valid start pattern.
3. Perform the encoding of the exact number of character pairs specified by the application per the following algorithm:
   a. Record the scan times (widths) across each of the ten elements of a character pair and accumulate their sum, S.
   b. Compute a threshold, $T = (7/64)S$.
   c. Compare the individual times to the threshold;
      if scan time $< T$, assume the element is narrow;
      if scan time $\geq T$, assume the element is wide.
4. Confirm the valid decoding of the character pairs.
5. After decoding the proper number of character pairs, confirm the presence of a valid stop pattern and trailing quiet zone.
6. Perform such other secondary checks on quiet zones, beam acceleration, absolute timing dimensions, and so forth, as are deemed prudent and appropriate considering the specific reading device and intended application environment.

Appendix C

Optional Characteristics of USS-I 2/5

In USS-I 2/5, the start and stop patterns can be found as the respective end and beginning of encoded pairs of digits within the code. There is, therefore, no guarantee that a partial scan of the symbol will not produce a valid read for an imbedded symbol having fewer characters. For this reason, USS-I 2/5 should not be used in an application where the length of the symbols must vary.

A user can improve the security of the USS-I 2/5 symbology through the addition of a check character. It is recommended that the added check character be calculated as a modulo 10 check digit based on alternate 1, 3 weightings of the data characters. The weighting is arranged so that the least significant digit is on the far right of the data stream and receives a 3 weight. For example, the check character will be calculated as follows:

Data Characters - 4 3 8 2 7
Weights - 3 1 3 1 3

Weighted Sum = (3×7) + (1×2) + (3×8) + (1×3) + (3×4) = 62

The check digit for the data characters is the digit which added to the weighted sum produced a sum ending in 0. Hence the check digit for the example is 8. The check digit is appended as the least significant digit to produce the result:

Data + Check Digit = 4 3 8 2 7 8

Note that a leading zero will be required if an even number of data characters are to be appended with one check character to produce a result with an even number of characters.

Appendix D

Human Readable Interpretation

USS-I 2/5 should have a human readable version of the numeric characters which are encoded by the symbol. The printed digits should appear above or below the bar code symbol. There is no specification on the size or font which can be used. The presentation should include all numeric characters in the code including leading zeroes. No special character should be used to represent either the start or stop character in the code.

The figure below illustrates a typical USS-I 2/5 symbol incorporating human readable text.

00553923

Figure 6

Appendix E

Auto-Discrimination Compatibility

USS-I 2/5 may be read by suitably programmed bar code readers that are designed to auto-discriminate it from other symbologies. The code is, in particular, fully distinguishable from and thus compatible with:

USS-39
USS-93
USS-128
USS-Codabar
UPC
EAN

When USS-I 2/5 is used in an auto-discrimination environment with USS-39 symbols, the following guidelines must be followed:

1. The nominal intercharacter gaps in the USS-39 symbols must be no wider than the narrow elements.
2. The reading system must be constrained and the decoder programmed to insure that the number of characters (including start and stop characters) in all USS-39 symbols be greater than one-half the number of data characters in the USS-I 2/5 symbols.
3. While USS-I 2/5 symbols have a minimum fixed length of two characters, they should have a minimum of six characters in auto-discrimination environments.

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

Appendix F

Systems Considerations

It is important that the various components (printers, labels, readers) making up a bar code installation operate together as a system. A failure in any component, or a mismatch between them, can compromise the performance of the overall system.

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

X Dimension

In closed systems, the X dimension may be less than 0.0075 inches (0.191 mm). The user must exercise care in these systems to assure a match between the reader resolution and printed symbol X dimension.

Bar Height

In closed systems, bar heights less than 0.25 inches (6.35 mm) may be printed.

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.

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 exercised to assure that the optical properties are within specification over the entire range of read angles and distances required by the particular application.