BAR CODE TYPES

The popular bar codes in use today are UPC/EAN/JAN, Codabar, Interleaved 2 of 5, Code 39, and Code 128. The UPC code is widely used in the grocery, drug, and various point-of-sale applications. The Codabar code is widely used in the blood industry. Interleaved 2 of 5 is listed as a standard for the corrugated industry. Code 39 is widely used in the manufacturing industry and is the LOGMARS (Government) standard.

BAR CODE TERMINOLOGY

Start and Stop Characters

These characters are at the beginning and the end of the bar code symbol. They indicate to the scanner the direction from which the information is being received. This allows for bi-directional scanning, therefore it does not matter if you scan left to right or right to left.

Bar-Space Patterns

These patterns represent the encoded information in terms of bars and spaces. Most bar code symbologies have simple structures, meaning they consist of only wide and narrow elements. This is true for both bars and spaces. The narrow element or the minimum bar width is called the “X” dimension. This “X” dimension is critical when selecting a printing technique for bar codes. The smaller this dimension, the shorter the symbol, the closer the tolerances, and the more difficult it is to print. Bar code specifications indicate the ratio that must exist between the wide and narrow elements. A ratio of 3:1 indicates that the wide elements are “3X” as compared to the narrow “X” element. Exceptions to the simple wide and narrow pattern codes are structurally complex codes like UPC and Code 128, which have four different sizes.

Intercharacter Gap

Some bar codes are “discrete” in the sense that each character is printed independently of the other characters and separated by a space that is not a part of the encoded character. This space is called the intercharacter gap. For “continuous” codes there is no need for intercharacter gaps since all of the spaces are parts of characters and carry necessary information.

Quiet Zones

This is the area immediately adjacent to the start and stop characters which contains no markings at all. It is these quiet zones, coupled with the pattern of bars and spaces, that the scanner recognizes or decodes as a legitimate bar code. The quiet zone space should be at least ten times the width of the narrow bar or space (“X” dimension). If this distance is too short, the scanner will not recognize the code and will not read the symbol.

Interpretation Line

This is the human readable information printed directly beneath the bars and spaces. They are the characters that are encoded in the bar code symbol.
SYMBOL ENCODING INFORMATION

Each bar code symbology has its own unique way of encoding information. The more error free codes are structurally simple, since the bars or spaces are either wide or narrow. The wide elements normally have a value of “1” and the narrow elements have a value of “0”. An examination of Code 39 and Interleaved 2 Of 5 is shown as follows:

**Code 39**

Each character is represented by 9 elements; 5 bars and 4 spaces. Three (3) of the nine (9) elements are always wide. The narrow bars and spaces are the same width, and the wide bars and spaces are the same width, each of the latter being three times the width of the narrow components. An example of the number 9 is shown below. The configuration is 001100100. The characters are separated by an intercharacter gap since Code 39 is a discrete code.
**Interleaved 2 of 5**

Each character is represented by 5 elements; 5 bars or 5 spaces. Two (2) of the five (5) elements are wide. Any given bar/space pattern encodes 2 characters. One character is encoded in the bars and another is encoded in the spaces. The bars are coded for numbers which appear in the odd position of a message, while the spaces are coded for those numbers which occur in the even positions. The one character is "interleaved" between the other. An example of the number 25 is shown below. The number 2 is encoded in black bars, the number 5 is encoded in the spaces. The configuration for 2 is 01001 and for 5 it is 10100. Interleaved 2 of 5 is continuous code so there is no intercharacter gap. A leading zero is used in those cases where an odd number of digits must be encoded.
CODE DENSITY

Code density refers to the number of characters per inch. There are four variables that affect code density. These are: type of code, ratio of wide to narrow elements, the “X” dimension, and the printing technique.

Type of Code – Some code structures encode more information per inch than others. For example, everything else being equal, Interleaved 2 of 5 can encode more information per inch than Code 39.

Ratio of wide to narrow elements – Varying the wide to narrow ratio can change the density of a given bar code. For example, Code 39 with an “X” dimension of 10 mils will have 6.28 characters per inch with a 3:1 wide to narrow ratio and 7.39 characters per inch with a 2.2:1 wide to narrow ratio.

“X” Dimension – Changing the “X” dimension can change the code density. As an example, with a Code 39 ratio of 3:1, an “X” dimension of 7.5 mils will give 8.37 characters per inch. An “X” dimension of 40 mils will give 1.57 characters per inch. There is no specific classification of density, but some authors use the following guide for classification.

<table>
<thead>
<tr>
<th>Density</th>
<th>“X” Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Density</td>
<td>10 mils or less</td>
</tr>
<tr>
<td>Medium Density</td>
<td>10 mils to 20 mils</td>
</tr>
<tr>
<td>Low Density</td>
<td>20 mils and greater</td>
</tr>
</tbody>
</table>

Printing Technique – Code density will be constrained by the type of printing technique used to produce the code. Printing techniques vary in the size of the “X” dimension, the wide to narrow ratio, and the type of code that can be produced.
RECOMMENDED CODES

The recommended codes for use in general applications and for employee badges are Code 39 and Interleaved 2 of 5. Code 39 presents the broadest use to industry. It is able to encode all alphabetic and numeric characters, is highly secure (better than one error in each $10^9$ characters scanned with modulus checking). It is widely implemented and is sanctioned by the corrugated industry, Department of Defense, ANSI, and the automotive industry. Interleaved 2 of 5 is highly secure (one error in each $10^8$ characters scanned with modulus checking), provides for high density, and its use is fairly widespread. It is, however, a numeric code and has more restrictive printing requirements because it is a continuous code. It is sanctioned by the corrugated industry, ANSI, and the automotive industry. Figure 1 shows comparisons of bar code symbologies.

![Bar code symbology comparison table](image)

Figure 1
SCANNING CONSIDERATIONS

When using manually operated wands to read messages, it is a fairly easy task for a person to move his hand at constant velocity without giving the matter much thought at speeds of between 3 and 50 inches per second. Below 3 inches per second, it is difficult to maintain the required constant velocity and, when exposed to significant acceleration, the electronic circuits tend to lose track of what they are supposed to be doing. Speeds above 50 inches per second require calculated effort, and for that reason their possibilities have little value. In fact, most manual reading is carried out at velocities in the range of 10 to 30 inches per second, where the higher and lower limits merely provide a margin of safety.

When a person uses a hand-held wand, there is a tendency to start slow, speed up in the middle, and end slow. However, when a human uses an ID badge inserted into a fixed head reader, the tendency is to start slow and speed up continuously. In addition, the badge swipe is normally faster than the wand movement.

Electronically speaking, fast scanning of low-density codes has the same effect as slow scanning of high-density codes. The person prefers to move the pen or badge, particularly the badge, at a relatively high velocity. Moving at a low velocity seems to decrease first read rate acceptance. Therefore, it is better to have a low to medium density code ratio in order to insure high first read rate acceptance. A code that uses wide bars or spaces which are three times the width of its narrow bars or spaces (3:1) is more read-reliable than is one which uses a (2:1) ratio.

In the preparation of badges, it is recommended that medium density code be used (10 mils to 20 mils). At a density of 12 mils there are 5.21 characters per inch. This is a nominal density for good badge reading.

The size and location of the bar code for badge reading is outlined in the brief entitled “LINX Barcode Badge Physical Requirements”.