The Evolution of Bar Code Verification

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Label Vision Systems, Inc.

The process of checking the quality of a bar code symbol according to an accepted industry standard is called *BAR CODE VERIFICATION*. In the early seventies, the first bar code symbol verification guidelines were defined by the Uniform Code Commission (UCC). These guidelines are called "Traditional Measurements". Traditional Measurements generally consisted of three objectives:

OBJECTIVE 1: Establish the print contrast signal ratio (PCS) and make sure it is greater than 75%.

OBJECTIVE 2: Measure bar growth and make sure the growth is less than or equal to 25%.

OBJECTIVE 3: Visually inspect the bar code symbol and look for spots or voids.

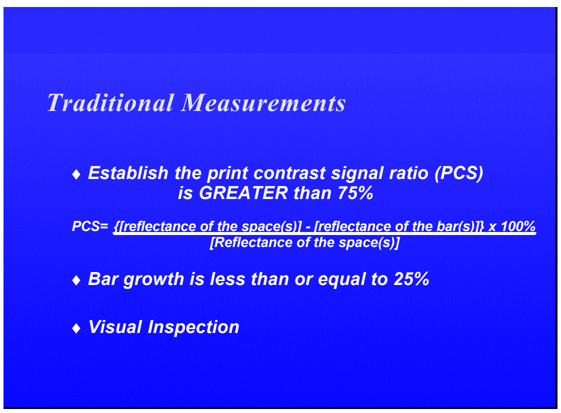

Figure 1: Traditional measurements

As time went on, printing companies began to understand that these so called "Traditional methods" for verifying the quality of a bar code symbol did not work that well. In many situations they would indicate good symbols as being bad….as well as bad symbols were determined to be good. A change in bar code verification methodology was needed.

In 1982 the American National Standard Institute (ANSI) started a committee to study the issues of bar code print quality. This outstanding group of engineers concluded their 8 year study by publishing a document called ANSI X3.182-1990 Bar Code Print Quality Guideline. They concluded that the correct way to measure the quality of a bar code symbol was to base all measurements upon what the scanner sees electronically, not what the human eye sees. A scanner will see a bar code symbol as a series of DC variations along a time line. The committee would call this a "Scan Reflectance Profile" (SRP). Quality measurements were now to be taken with respect to this profile reflectance technique. The Uniform Code Commission (UCC) and the National Institute of Scientific Testing (NIST) have adopted these ANSI guidelines as their standard. A copy of these guidelines can be obtained from various groups concerned with bar code quality. Here are three of them:

AIM USA 634 Alpha Drive Pittsburgh, PA 15238 1-412-963-8588 http://www.aimusa.org	Uniform Code Council 7887 Washington Village Dr Suite 300 Dayton, OH 45459 937-435-3780 http://www.uc-council.org	CEN European Committee for Standardization 36, rue de Stassart B-1050 Brussels, Belgium +32 2 550 0811 http://www.cenorm.be

In addition to these written guidelines there is a company called Applied Image which has manufactured a set of bar code labels designed to give us calibrated ANSI standards for contrast, modulation, spot defects, void defects, decodability bar, and decodability edge.

This set of 32 UPC Primary Calibration Standards contain a sample of 5 different grade levels ranging from A to an F for each of the six areas. These Primary Calibration Standards are recognized by ANSI, NIST, and UCC as a certified representation of quality variations according to the ANSI X3.182 specifications.

Fig. 2: Applied Image, Inc. address and phone

Fines imposed on printers

All of these quality checks were created to insure a 100% accurate read when scanned at the retail outlet or warehouse. When a bar code symbol fails to read or to read the correct number, an avalanche of costly errors are created. It first starts when a manual entry of the corrected bar code data is attempted. Tests have shown that the keyboard entry error rate is 1 out of 100 characters. The resulting errors will cause the controlling system to price products wrong, subtract wrong items from stock, and then fail to subtract the right item from stock. Now the inventory is out of balance as well as the customer has been incorrectly charged. Now the wrong inventory levels will result in re-ordering products based on miss-information.

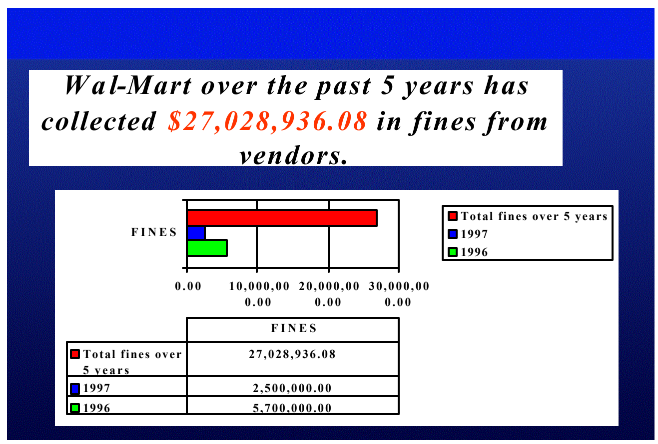

Fig. 3: Fines imposed by Wal-Mart

The same thing will occur when products are miss-labeled. The bar code label reads just fine but it has wrong UPC code. This type of error is, typically, more costly than the first since it will go undetected until perhaps thousands of consumers have been charged the wrong price. The problem is created when the print house is fulfilling an order for labels. The customer wants 100000 labels. The operator has 75000 labels on one roll then splices in another 25000 with labels that look exactly alike. The only difference is perhaps one number on the UPC code. The best of operators may not catch this very common mistake. Now the roll of toilet paper has turned into a can of baked beans. And the avalanche of errors, once again, begins.

Yet another common problem is found with store coupons that have the wrong UPC bar code on it resulting in unintended huge discounts.

The problems created with bad bar code labels is serious enough for major retail outlets (K-Mart, Sears, Krogers, Wal-Mart, Marshals, Rubber-Maid, etc.) to impose a fine on printing companies for a substantial amount of money. From 1993 to 1997 Wal-Mart alone collected over 27 million dollars from their vendors

The Scan Reflectance Profile

The SRP is an analog electronic signal which is generated by reflecting a light source off the surface of a bar code image and then collected or detected by a light sensitive diode or a series of diodes. The resulting signal represents the bars and spaces of the bar code symbol. Figure 3 shows a bar code label with it's equivalent SRP of one scan across the symbol.

ANSI decided that there are eight major attributes which affect the quality of a Scan Reflectance Profile. They are: Edge determination, Minimum Reflectance, Symbol contrast, Minimum edge contrast, Modulation, Defects, Decode and Decodability.

Fig. 4: The Scan Reflectance Profile

In addition, there are some other areas of concern which are hard to measure with the reflectance profile formulas and is therefore necessary to visually check for, specular reflectance, opacity, truncation of bar height, OCR correlation, porosity, and smoothness of surface.

The Modern Verifier

It is a safe assumption that all printing processes will develop mechanical problems now and then which will create unreadable bar code symbols. It is not a question of "if" your printer will make bad labels, it is a question of "when" . Will you know when this happens? Will you know why?

In order to measure the quality of a bar code symbol, label manufacturers will need to purchase a measuring device called a "verifier". A verifier is an instrument which measures the quality of a bar code symbol's SRP according to the specific ANSI specifications outlined in the ANSI X3.182.

A recent study was undertaken by the Research Department of Label Vision Systems, Inc. The question was, 'do verifiers actually work'? To find the answer, a set of Primary Calibration Standard labels were used to test 106 verifiers across North America at their location. It was found that only 25 worked according to the ANSI specifications. The rest were generally not representing the true ANSI grade. And, none of them were properly certified.

There are several companies who make verifiers. Generally, all of them were made to correctly measure bar code quality but certain procedures must be in place for them to work correctly on a daily basis. The following should be taken into consideration:

1. A verifier must be certified. Certification of a verifier can only be accomplished by using a set of calibration labels called Primary Calibration Standards made by a company called Applied Image. There will be a "Certificate of Compliance" associated with any new verifier. This certificate will list the serial number of the calibration labels used to certify its compliance with ANSI X3.182. (There is a later version of this documentation called X3.182-1995.) If this certificate does not exist, then it is not a certified verifier.
2. A verifier must be calibrated and re-certified at least once a year. Once again, a set of Primary Calibration Standards made by Applied Image is the only way a verifier can be certified.
3. The operators performing the actual inspection of a bar code symbol must be trained. There are a multitude of ways an operator can acquire false information using a verifier. This would include using the wrong aperture, scanning at the wrong angle, scanning too fast or too slow, ambient light, scanning surface, and more.
4. The operator will be trained to periodically check the contrast levels using a calibration label supplied by

the manufacturer of the verifier. This contrast test label must be kept in pristine condition or you will distort the ANSI grade. If this calibration label looks dirty, throw it out and buy a new one.

Good bar code labels that cannot be read

Not all reading errors are a result of something going wrong with the printing process. This is very important to understand. Two of the most common reasons for this are ***Label Placement*** and ***Opacity.***

Opacity is defined as the ability to see through a substrate. Opacity becomes an issue with plastic; a common packaging material that is very thin, very flexible and very much "see through". A verifier (on-line or off-line) will check these bar codes as good. However, when placed on the actual product, the background of the spaces between bar elements would change to the color of the product. An example would be a loaf of bread. Without the bread, the spaces of the bar code symbol show a high reflectivity since there is nothing behind the symbol to see. When the BROWN crust of the bread is placed into the package, the background of the symbol is now brown which will dramatically reduce the ability to read this label.

The marriage of product and package can and will change bar code quality. To prevent this is simple: when verifing the quality of a bar code, make sure the intended background for that product is well represented. For instance, to verify the quality of a bar code label while it is wrapped on a loaf of bread might be a real challenge. Instead, create a back plate that accurately represents the crust of bread and then place it behind the empty wrapper when being verified.

Label Placement is yet another very common reason why a label fails to read at a retail outlet store.   It is defined as " The position of a bar code symbol after the product and the bar coded package are assembled". An ***in-line verifier*** or an ***off-line verifier*** would check the bar code symbol as "good" when in reality the package design has caused the bar code image to be too close to the edge of the product thus rendering it unreadable.

Another common problem in label placement is with respect to curved surfaces. The bar code symbol must be placed on the curved surface so that the bars of the symbol follow the curve. Once again, any verifier used to check for label quality would see it as a good grade on the press. However, when placed on the curved product surface, it becomes unreadable at the grocery store. These types of problems must be taken into consideration when the package is designed.

Fig.5 Good placement of bar

Fig.6 Unreadable due to placement.

Errors Created by the Printing Process

Flexographic presses will develop uneven plate pressures and gummed up plates. Changes in ink viscosity, over inking, matching the ink to the substrate is always a challenge. Each one of these typical mechanical issues will develop unique bar code errors. (see fig. 7).

Those who print variable data directly onto the substrate, such as Ink Jet or Ion Deposition will have yet another list of unique issues that will result in bad bar codes during a production run (see fig. 8). Ink splatters…..ink spreads…..streaking…..blooming…..blocked jets; and there are more.

The challenge for bar code label manufacturers is how to achieve a 100% quality inspection throughout

Fig. 7: Ion Deposition printing process errors

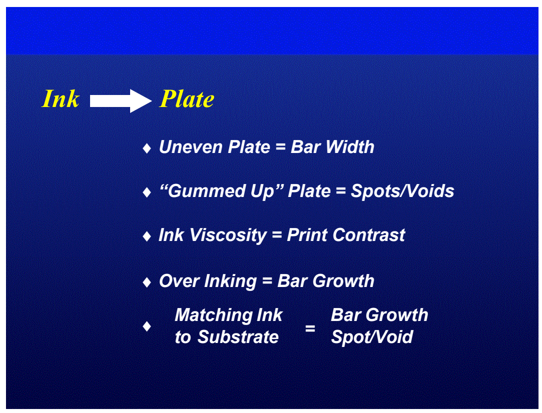

Fig. 8: Flexographic printing process errors

This brings us to the main reason for this article. Today, technology has improved to where ***IN-LINE BAR CODE VERIFICATION***, whether on a printer, rewinder, or on the final package is here and should be considered.

IN-LINE BAR CODE VERIFICATION

There are three types of products that are available to perform formal in-line verification. Laser based, Traditional Vision, and Real Time Video .

Laser based Verifiers

One of the ANSI requirements for obtaining an accurate ANSI grade is to scan a bar code symbol at 10 different, evenly spaced positions. As can be seen on this chart, achieving at least 10 scans per symbol is almost impossible to do when higher web speeds are required. Laser based verifiers should therefore be used for in-line verification when speed and orientation are not critical. Fig. 9 shows the levels of web speed which can be achieved verses the laser read head's "scans per second" capability.

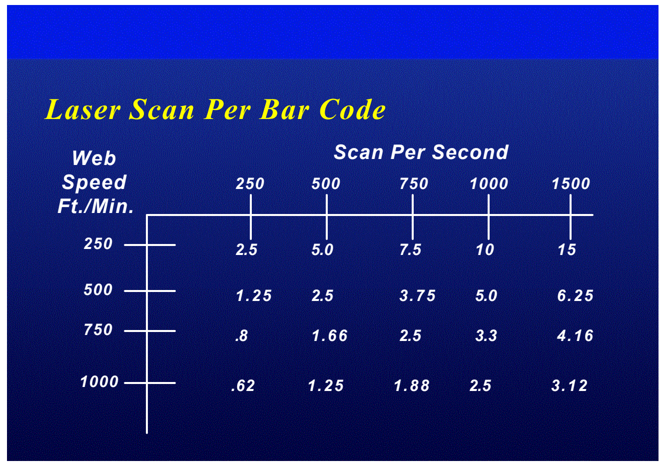

Fig. 9: Laser scans per bar code symbol

Label orientation is also critical with a laser based system. As Figure 11 shows us, the "ladder orientation" will scan at a few bar height positions depending on web speed. However, when the bar code image is placed in the "picket fence orientation", a laser based system can only scan one single line through the middle of the symbol. That leaves virtually 99% of the bar code symbol unchecked for print quality.

Laser based verifiers are able to check the quality of a bar code symbol at speeds greater that 250 feet per minute is limited to examining only .02 inch of TOTAL bar height (see fig. 10)

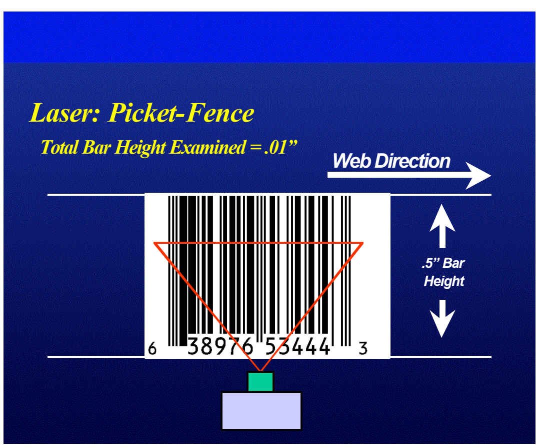

Fig. 10: Laser bar height examined

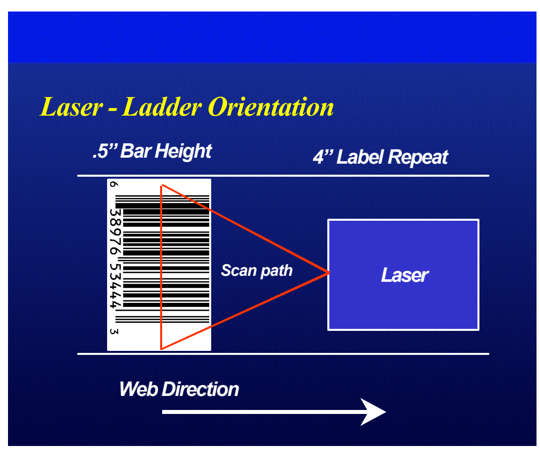

Fig.11: Laser scan line verses label orientation

TRADITIONAL VISION SYSTEMS

Traditional vision systems have been around for a while and each year, due to the advances in computer technology, it is getting even better. The strength of vision technology is that it captures the entire height of a bar code symbol and holds the image while formal ANSI verification can be completed.

Label orientation is also not an issue. The image is captured just as well in the ladder orientation as well as in the picket fence orientation.

Spots and voids are easily detected.

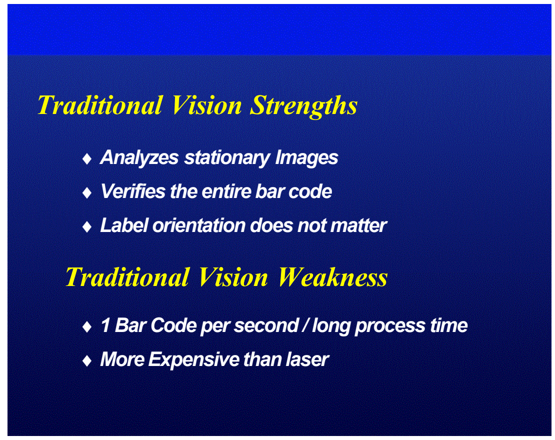

Fig. 12: Traditional Vision based systems

Some concern when using a Traditional Vision Verification system is with the degree of difficulty for an operator to setup. Vision systems are typically viewed as a high-tech, high maintenance solution. They would rather not go down this path. Print houses want to push a button, run the job, and output the results on a report. Print houses that typically print the same type of label are a good candidate for a vision based system. Once the image is set up, the software does not require any changes. However, if you need to verify many sizes of bar code symbols, an in-depth knowledge of vision based software may be necessary to change from one job to another.

A major concern with Traditional Vision is that it can only capture one ANSI grade bar code symbol per second. Please refer to Figure 13. This chart outlines how many different bar code symbols can be ANSI graded at various typical web speeds. As can be observed, any speed greater than one symbol per second would mean that 100% ANSI grading is not taking place. But inspecting every twentieth label or so is better than what most printers do today…..and that's to check the first and last symbol of a job and let the rest go.

Traditional Vision

Web Speed Ft. Per Min.	Bar Codes Per Second	# of Codes Verified Per Second
250	12.5	1
500	25	1
750	37.5	1
1000	50	1

Fig. 13: Traditional Vision ANSI verification

REAL TIME VIDEO DECODING

The third type of in-line Bar Code verification technology is called "***Real Time Video***" decoding. It is very similar to traditional vision methods but with one huge difference. Real Time Video Decoding does not use bit mapping or freeze framing techniques and is designed to process all data as it happens or in….. ***REAL TIME***. It is equivalent of using 255 laser scanners on every single label that is seen by the read head.

A standard NTSC black and white video camera collects the image of 60 different bar code symbols per second. Each of these 60 images is made of 255 contiguous scan lines. This enables examination of a new bar code every 16.67 ms while creating a scan reflectance profile for every .006 inch bar height (see Figure 13). A typical 100% UPC bar code symbol will be contiguously scanned 145 times during one field of time. This enables the operator to know the quality of the entire label as well as detect ugly blemishes caused by the printing process. This kind of scanner resolution allows the operator to spot trends in print quality before it becomes a problem.

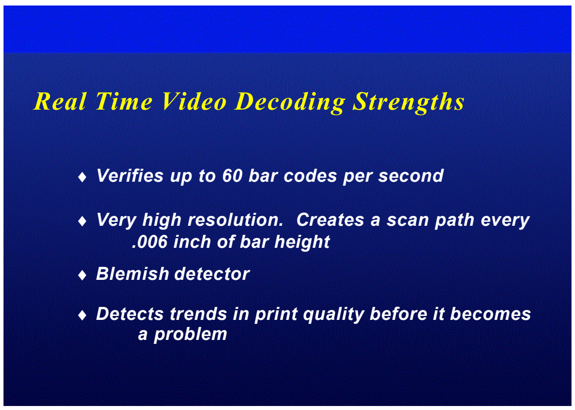

Figure 13

The weaknesses to ANSI grading with ***Real Time Video*** Decoding are two-fold:

1. The single lane system can only ANSI grade 60 different bar code labels per second. Printers who print small labels will need to slow down their printing process in order to achieve 100% inspection. See the speed chart on Fig.16.

2. All ANSI parameters are measured during an inspection. But, when an error occurs, ***Real Time Video*** does not know what ANSI specification has been violated. Software reports the true ANSI grade along with bar growth/shrinkage measurements but it doesn't report why the error has occurred. An off-line verifier must be used to understand what kind of error has occurred.

The strength of ***Real Time Video*** verification can be best described by Figure 16. Notice that ***Real Time Video Decoding*** scans a .5" high symbol 145 times no matter what web speed or orientation is required. This type of scan resolution not only ANSI verifies, but will also detect any blemishes in the bar code symbol. Traditional verifiers do not know when a blemish is present. This is because the blemish caused that particular scan line to be non-existent . ***Real Time Video*** verification checks every .006 inch of a bar code image contiguously. Any blemish greater than .006 inch will be detected and reported.

Perhaps the most important feature with ***Real Time Video Decoding*** is it's simplicity and user friendliness. Here is the entire SETUP procedure:

1. Position the read head so the bar code label is in the field of view.
2. Push the SETUP button.
3. Set the ALARM SCREEN to output an error signal.
4. Push START to RUN the job.

Software does the rest. Within 15 seconds the job is ready to run….at any speed….in any orientation.

Conclusion:

Years ago, 100% bar code verification could not be achieved. Now, however, both laser based and vision based systems can accomplish this. With the cost of fines being imposed by the major retailers increasing, it would be a safe bet that the cost of installing an in-line verification system would be less than the cost of being fined only once.

100% bar code verification is finally here

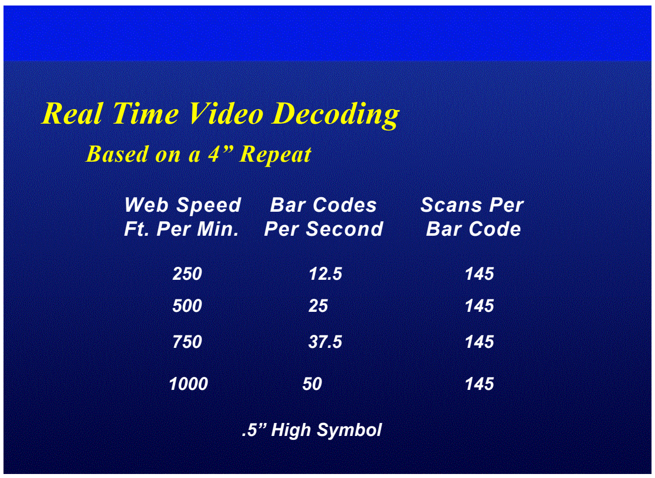

Figure 16

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