Machine Vision Consulting
Inspiring Vision Across Industry

CodeSure® Printed Code Verification and Inspection Technology

Prepared by:
Machine Vision Consulting

Contact:
Joe Gugliotti

7 Old Towne Way
Sturbridge, MA 01518

(978) 551-4160
sales@machinevc.com
www.machinevc.com

Executive Summary

MVC has developed a wide variety of turn-key solutions based on its machine vision experience and expertise. This paper will discuss the **CodeSure®** solution, developed to verify the correctness, legibility, and position of codes that are printed onto a specified substrate or object.

The printed codes may contain important manufacturing information that must be printed correctly and must be legible to the distribution chain or to the end user:

- Lot code
- Date code
- Product code
- Machine or plant code

The **CodeSure®** solution developed by MVC will:

- Enhance the operator experience for code or format changes.
- Tolerate moment-to-moment variations in the appearance of the printed characters.
- Use proprietary **CodeSnap©** technology to adapt to additional changes in the code appearance, for instance after ink-jet head servicing.
- Import electronic font files to automatically train characters for verification and inspection.
- Help maintain system validation.
- Verify rotated codes, such as those on can ends or lids.
- Provide operator feedback through a stack-light array for remote monitoring.

Machine Vision Consulting, Inc. is based in Massachusetts, with a lab building in Westborough, MA. MVC is focused on the integration of machine vision technology to provide automated inspection and process control during manufacturing and packaging in a wide variety of industries.

- **End users** come to MVC for complete machine vision solutions.
- **Machine builders and automation integrators** work with MVC to develop the machine vision portion of their overall assembly, processing, handling, coding, or packaging solutions.
- **OEM's** of packaging systems, code printers, robotics, semiconductor testing systems, and other process systems work with MVC as an extension of their engineering organizations to design, install, and support machine vision system options.

MVC's engineers are based in Massachusetts, New York, North Carolina, Ohio, Oregon, and Arizona.

As the vision industry has matured with easier-to-use products, one thing remains the same - *vision projects are inherently complex*. The development and deployment of a vision system requires a team of experienced vision engineers that can avoid potential problems that arise when combining high technology from multiple domains (i.e. PLC communications, robotics, vision architecture, real world lighting and optics, motion control, sensors, rejecters, human intervention, and controls).

Introduction to Code Verification

The focus of this paper is on using machine vision for the verification and quality inspection of alphanumeric codes that have been printed onto some specified substrate. By verification, the goal is that the machine vision system will automatically confirm that the expected code has been applied to the substrate and is legible. The printed code may contain a lot code identifier, an expiration date, a product code, a plant code, or some other important production information. Any container that does not contain the expected code information or that is determined to contain illegible print will be kicked off the production line.

The printing methods used to create the codes include the Continuous Inkjet Printer, the thermal transfer printer, the laser, and other printing technologies. While these methods generally produce codes that are acceptable visually, the printing processes or the motion of the substrate often create inherent variations in the appearance of the codes, which make the application of automated code verification more challenging.

The substrate itself can contribute to the variations in the appearance of the codes. These substrates may include flat can ends, ridged can ends, concave beverage or aerosol can ends, lids, shrink sleeves, plastic bottle bottoms, carton sides, bags, vials, plastic containers, or other substrates.

Why Is Code Verification Important?

1) Code verification facilitates the execution of a product recall. If the printed code is incorrect, missing, or illegible, the producer has no way to verify the pedigree of the product, nor does the consumer. All traceability to a lot code and expiration date is lost once that product leaves the printer with an illegible, incorrect, or missing code.

The lack of codes has caused some producers to be forced to recall everything made because un-coded product has made it to the consumer.

2) Code verification is critical for bright-stocking. Unlabeled, but coded, generic product is sent to a warehouse for storage until a customer requests that particular product. The product is then brought into a labeler and printed code verification is required to assure the consumer that the appropriate product container receives the appropriate label. This is especially important for contract packagers.

Cans are blind items and the printed code provides the only way to know what is supposed to be inside. Vials may contain a clear liquid that cannot be identified by looking at it. Bottles with tamper seals all look the same in their unlabeled form except for the printed codes that may be on the bottle.

3) Code verification is important to consumer safety. In that cans are blind items, mixing up a soy product with a milk product or mixing clam chowder with chicken soup can lead to serious consequences to the consumer and to the packager. If drugs are involved, correct product identification becomes critical and contributes to E-Pedigree conformance and patient safety.

4) In addition to characters that are acceptably mis-shaped, incorrect characters may be present. If an incorrect code is being printed and the printing error is not detected quickly, the loss can be substantial, perhaps an hour or two of production that must be destroyed because its history cannot be verified. Once a product is marked incorrectly, it generally has to be destroyed, as its pedigree can no longer be guaranteed.

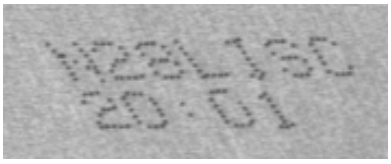
5) Code verification can help to eliminate refused and returned products. In many cases, the product being marked must have a correct, legible, and properly placed code. If the code does not meet the marking requirements on a small number of samples, the entire pallet of product may be refused and returned. There is a real cost to the packager of absorbing returned product and issuing replacement product. This is especially true on exported products.

Given these issues, CodeSure® can become the critical component of a code verification solution. If a character is so distorted that it is unreadable, the code needs to be rejected. However, an acceptable level of printed-character distortion must be tolerated by an automated verification system to minimize false rejects and maintain the yield of the line. In addition, the physical placement of this code relative to some reference point (for example, the edges of a can) must often be inspected along with the code verification.

How And Why Do Printed Codes Vary In Quality?

It is normal for many on-the-fly code printers to suffer random variations in the appearance of their printed characters; there are many process setup variables, such as line speed variations, marking head misalignment, package shape, nozzle distance, and other factors. Thus, the yield of the vision system used to verify the correctness or legibility of these critical printed codes is a key contributor to the yield of the line – how often you get the correct answer, whether it's Pass or Fail, even when the individual characters or the entire string varies in appearance because of processes one cannot always control.

For example, with ink-jet printers, this character-quality fluctuation is often a result of the human interaction with the print head set-up, especially after cleaning or servicing. The print head must be installed straight or slanted print may result. The distance between the print head and the object must be consistent between runs or the size of the characters can change. In the worst case, the print head is clogged or is out of ink, creating a situation of "no code" or illegible codes.



Code Skew Caused by Crooked Installation of the Print Head

Why is Automated Character Verification Difficult?

With typical Smart Camera-based solutions, the characters of the font being used are trained by acquiring images of every character under varying conditions and building up a statistical model of what each character looks like. This type of character training also includes the background behind each character in the trained model. In a production situation where the characters exhibit moment-to-moment variations in appearance and have varying backgrounds, this image-based font training would be a never-ending process. Also, the need for ongoing manual image-based training may invalidate a code verification solution.

Introduction to More Reliable Code Verification

Font and Character Training

As noted above, with most Smart Camera-based solutions, the characters of the font being used are trained by taking images of every character under varying conditions and building up a statistical model of what each character looks like.

With MVC's CodeSure® solution, the same electronic font file that the code printer uses is imported into the CodeSure® solution and is used for automated character training. TrueType™ or Microsoft™ Windows™ fonts, often used with thermal transfer printers, are examples of electronic font files CodeSure® can import.

Most ink-jet printing systems are utilizing an electronic font description file. CodeSure® uses the same file to synthetically train the shapes of the character models without the need to create or use training images.

With CodeSure®, character training involves selecting a font file to import, automatically making the trained characters in the CodeSure® solution look the same as what the printed characters should look like. At run time, the CodeSure® algorithms compensate automatically for any acceptable moment-to-moment variations in the appearance of the characters in the printed code.

In addition, MVC has implemented a proprietary function called CodeSnap©. CodeSnap© can be initiated by the operator, primarily after ink-jet print head servicing, and provides additional automatic character distortion training on the first sample that passes through the CodeSure® solution.

The font file import function contributes to robustness, ease of use by the operator, and the maintenance of system validation. The following are examples of Continuous Ink-Jet Printer font files that can be imported:

Xymark – Simplex, Simplex A, and Simplex Roman using .vf or .vb files.
Domino – Arial, OCR-A, OCR-B, and Roman using .cst files.
Videojet – 5X7, 7X9, 10X16 using .xcl files.
Markem – 5X5, 5X7, and 10X16 using .ffm files.

Additional font files used by a printer can also be imported or a new font file can be created as required.

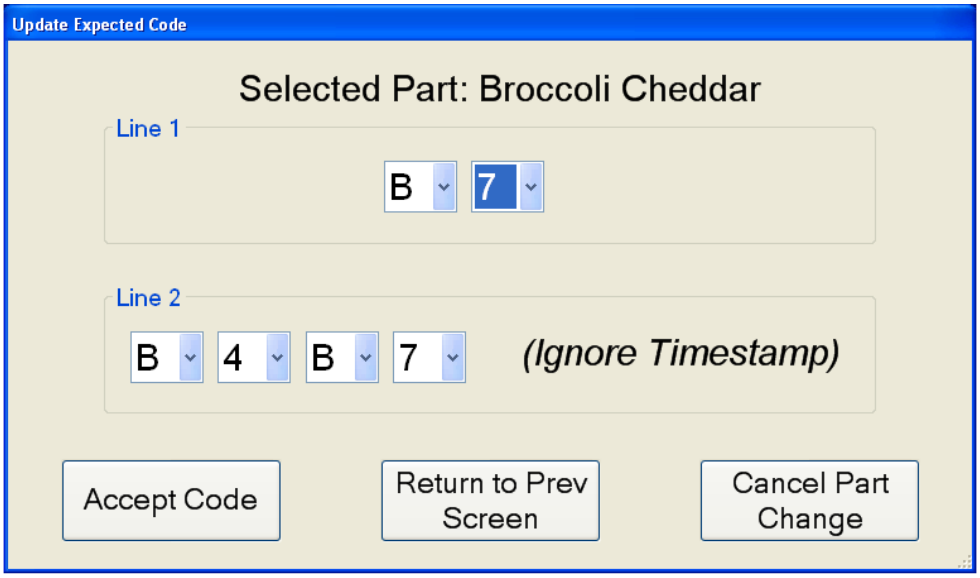
CodeSure® Operator Interface

This document will not delve into the finer points of using the CodeSure® solution (the CodeSure® manual does that), but CodeSure® has been developed to make it easier for an operator to:

- Select from a pre-trained menu of code formats or products that may be printed.
- Update the code content to be verified.
- Automatically allow CodeSure® to further train itself to handle what the code looks like in the production run using MVC's CodeSnap© function, useful after print-head servicing
- View a warning on a stack-light when a code fails verification.
- View a separate critical warning on the stack-light when some specified number of codes fails verification out of *n* samples, indicating a printer failure.

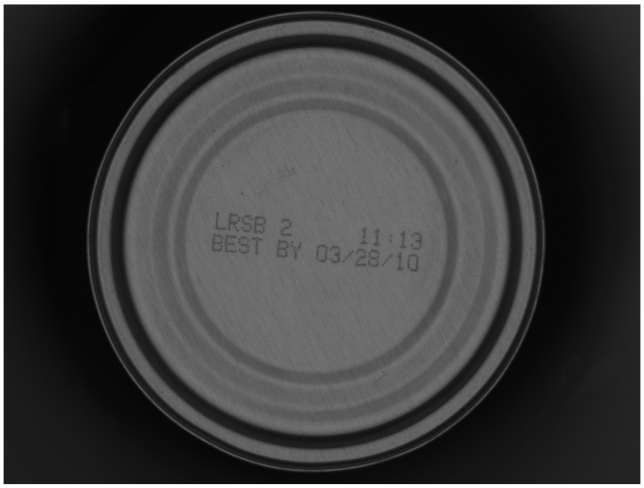
Each CodeSure® system will be custom-tailored to the user's requirements in terms of codes, code formats to be trained, products to be trained, characters to be ignored (such as time-stamps), code placement, and the substrate to be printed (lighting).

Example of Code Entry Screen:



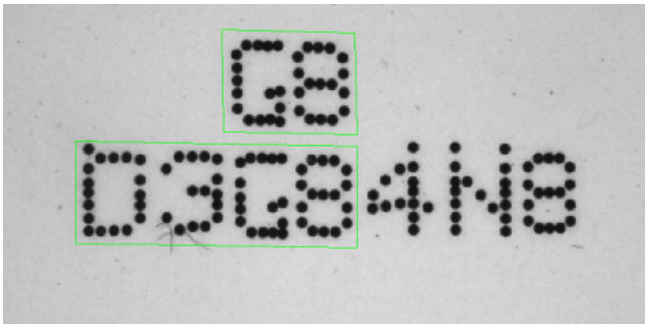
Example of Primary Operator Interface:

Code Examples:



Can End

Concave Aerosol Can Bottom



Flat Cardboard Box

Pharmaceutical Label

CodeSure® Benefits

- The operator interface is designed for ease-of-use and ease-of-changeover.
- Font training is done automatically through file import, not through manual image-based training.
- Code background variations don't affect the verification process.
- Codes are verified despite normal and expected random printing variations, while rejectable codes, whether incorrect or illegible, are failed.
- The CodeSnap©. function can be initiated to provide further automatic character distortion training that may be beneficial after ink-jet head servicing.
- Rotated codes can be verified.
- Lighting can be custom-designed by MVC for the container to enhance the code verification process.
- Line yield is kept high by accommodating acceptable character variations caused by the printing process.
- System validation can be maintained by eliminating manual character training.

Conclusions

The cost of verifying that the expected code has been applied to a container can be easily outweighed by the cost of a lawsuit, a recall, or a product return. Consumer safety, allergen prevention, and pedigree tracking are at the top of the priorities list for many manufacturers. Whether it's a matter of life and death or a consumer's inconvenience, today's manufacturers are making sure that their product is accurately coded.

MVC can demonstrate the CodeSure® solution, using a client's actual sample product, over the web. This provides an opportunity for the client's team to see CodeSure® in action and to further clarify the application requirements. The next step can then be determined.

Every application is different and may require a different imaging enclosure, may differ in line speed, may require wash-down capability, and may vary in any number of ways. MVC will work with its clients to customize key aspects of a CodeSure® solution to provide the best possible match with the requirements of the application.

MVC is focused on providing turn-key integration of machine vision technology to provide automated inspection and process control during the manufacturing and packaging processes in a wide variety of industries. This may include alphanumeric code verification, 2D Data Matrix code reading, UPC code verification, closure inspection, label inspection, or many other areas in which to apply machine vision technology.

Additional information on Machine Vision Consulting, Inc. and many of its products can be found on its web site, www.machinevc.com.

Call Joe Gugliotti at 978-551-4160 or e-mail sales@machinevc.com to initiate a conversation on CodeSure® technology or to discuss any other application of machine vision technology.