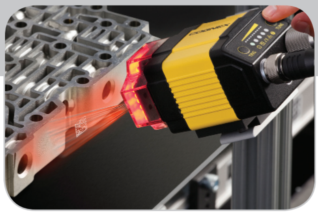
Expert Guide

Direct Part Mark Considerations for Automated Manufacturing Lines

Introduction

Part tracking or traceability is vital for those that make, store or move items through the supply chain because the data is used in production output calculations, inventory control, revenue forecasting and other business operations. Traceability also improves quality by ensuring that the appropriate processes are performed in the correct sequence on the right parts.

To track a part through its full lifecycle, manufacturers mark it with a permanent two-dimensional (2-D) code known as a Direct Part Mark (DPM). 2-D codes are used due to their small size, error correction and amount of data that can be stored as compared to traditional 1-D barcodes. 2-D DPM codes also help with anti-counterfeiting measures as they are more difficult to replicate. Automated image-based ID readers are the only technology capable of decoding such marks as laser scanners are only able to read 1-D linear barcodes. Automatic identification technology eliminates any need to manually enter data during production, avoiding human error and increasing efficiency.

On fully automatic manufacturing lines, parts are handled and moved by conveyor, indexer or robot and the ID reader is mounted in a fixed position where the mark can repeatably be placed in front of the reader. Similarly, a presentation reader operates in a continuous reading cycle, automatically performing the decoding task once the operator places the part in front of the reader.

This guide highlights the top considerations for implementing a DPM traceability process onto a fully automatic manufacturing line with fixed-mount code readers.

Code Selection

Industry standards groups define codes for a given application like ISO 29158 (formerly known as AIM DPM). The Automotive Industry Action Group (AIAG) has guidelines as do the Air Transport Association (ATA), the U.S. Department of Defense (DoD), GS1, SEMI and others.

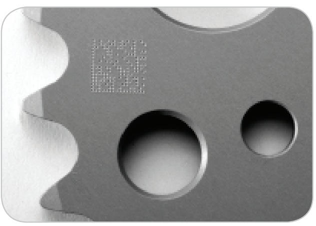
When specified, it generally makes sense to follow the industry guidelines because it improves efficiencies throughout product manufacturing and the supply chain. However, if no guidelines are available within your industry, you can use an existing guideline to create your own, noting that the Data Matrix ECC200 is strongly recommended and is clearly becoming the choice for most industries involving metal, glass, ceramic or plastic materials.

The Data Matrix ECC200 is very flexible as it offers 24 square formats and six rectangular formats to encode anywhere between six and 3,116 digits in a single code. It also supports Reed Solomon error correction which allows a code to be successfully decoded even though as much as 60% of the code may be damaged. Because this code is in the public domain, marking and reading equipment suppliers have invested significant R&D resources to improve the performance of supporting equipment.

Marking Processes and Placement

2-D DPM codes are marked on the part using several methods depending upon the material composition, part application and environmental conditions. Important factors influencing the marking process decision include part life expectancy, material composition, environmental wear and tear and production volume. Other considerations include surface texture, the amount of data to be encoded on each part, as well as the available space for, and location of, the mark.

DOT PEENING is achieved by striking a carbide or diamond tipped stylus against the surface of the material being marked.



Challenge: Reading solutions must utilize lighting techniques to create contrast between the indentations forming the modules of the symbol and the surface of the part.

Applications: Widely used in the automotive and aerospace industries due to demanding lifecycle requirements.

LASER MARKING applies heat to the part that causes the surface to melt, vaporize or change in some way in order to produce a mark.

Challenge: The resulting quality of the mark depends upon the interaction of the laser with the material it is marking.

Applications: Most often used in the semiconductor, electronics and medical device industries.

ELECTRO-CHEMICAL ETCHING (ECE) is a process whereby a mark is produced from the oxidation of metal from the surface being marked through a stencil impression.

Challenges: ECE is a time-consuming process and has a high cost for ongoing consumables.

Applications: ECE is used for low volume marking of round surfaces or for stress-sensitive parts of jet engines, automobiles and medical devices.

INKJET PRINTERS precisely propel ink drops to the part surface creating a permanent pattern of modules.

Challenge: Inkjet marking may require preparation of the part surface, as it is the chemical interaction of the ink to the surface of the part that determines the level of mark permanence and contrast.

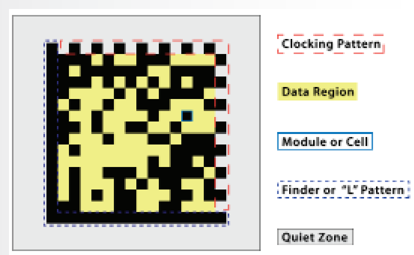
Applications: Inkjet marking provides fast marking of moving parts and offers very good contrast.

The location of the code on a part can directly impact the readability of the code. It should be clearly visible throughout the manufacturing process and, wherever possible, it should provide a "clear zone" free of part features and edges, noise/texture or other interference. Parts that present some of the most difficult reading situations include cylindrical or shiny parts that can create code distortion and specular reflection.

Anatomy of a Data Matrix Code

The features that comprise the Data Matrix symbol are the finder pattern, the quiet zone, the clocking or timing pattern and the data region. Each individual element is referred to as a module (cell).

The finder or L pattern consists of two orthogonal lines and is the key feature for the reader to use to locate the position of the code in the field of view.



The quiet zone is a clear area free of all other markings that surrounds the symbol on all four sides. For a code marked with a continuous L pattern (laser printed), the quiet zone width should equal the width of at least one module and for a non-continuous L pattern (dot peen, inkjet, chemical etch), the quiet zone should equal the width of at least four modules.

At the opposite sides of the finder pattern, along the perimeter, there are alternating dark and light modules known as the clocking or timing pattern. The configuration of the pattern of light and dark modules makes up the data region to be decoded by the ID reader.

Data Encoding and Readability

Data encoding refers to the amount of information that is "stored" within the generated Data Matrix code. Deciding on what information to encode is typically driven by the company specifications and/or the requirements of the traceability project. In selecting what data to encode, one should also consider the amount of available space on the part as code size can affect readability.

If the bumps on the surface of a cast part are similar in size and/or shape to the dot peen marks of the code, readability suffers because the code blends in with the bumps in the surrounding image.

Readability is a term used to define how easy or difficult it is for a reader to successfully read a code. If a code is not readable, the part is not processed and/or the production line stops. The capability of a reader to consistently read codes through the process is critical. Manufacturers live with varying read rates but should strive to achieve six sigma read rates which equates to only 3.4 defects per one million reads.

One factor that contributes significantly to overall readability is the quality of the mark. The process of inspecting the quality of a mark is known as verification. The verification process is defined within your industry's guidelines and generally takes place offline. Besides mark quality, you must consider other factors that can affect overall read rates. Understanding more about how a reader decodes the Data Matrix code will help.

Successful location of the code within the field of view is the first step in successful reading. The next step is for the reader to determine which modules are light and which modules are dark. A code pattern with modules that are consistent in shape and size and but distinctively different from other features on the surface of the part provide the most reliable decoding. However, due to the very nature of DPM applications, this can be challenging due to variations in the surface texture, variations in part presentation during the process, variability of the marking machines and changes that the parts undergo throughout their lifecycle.

Selecting a Solution

You have selected a code type, encoding data, process and location for the mark. Great. But your line may have to read DPM codes on parts that you receive from other suppliers, so you cannot guarantee consistent mark quality. How can you ensure you choose a reader that can handle your application?

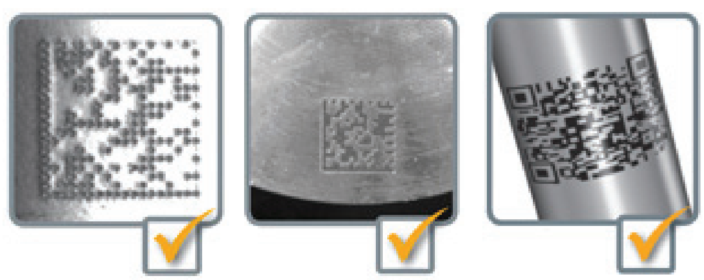
The most important requirement is for the readers on your line to provide high read rates, ensuring high throughput and complete traceability. There are three categories to review during your evaluation process to ensure the highest read rates possible: decoding software, image formation and ease of use. If your ID reader does not provide satisfactory features for these categories, we suggest you find one that does.

Three Categories of Evaluation

1. Decoding Software

Code reading algorithms form the basis for any image-based ID reader. As has been previously discussed, there are many variables that impact the readability of the code like distortion due to part material composition, variations in part presentation or variability caused by the manufacturing process. Powerful algorithms can read codes marked on any surface with any form of degradation. Test a solution with as many sample parts and variations that you can imagine.

But even the most advanced algorithms can perform better and faster with the help of resolution, lighting and optics.



we can read it™

2DMax+™ technology, a breakthrough in 2-D decoding software, handles a wide range of degradations to the appearance of DPM codes no matter what the marking method or surface.

2. Image Formation

A reading solution should tolerate changes in contrast, focus and degradation to the code without a need to change underlying parameter settings. Test your setup by adjusting the aperture or exposure to simulate change in contrast, focus to simulate change in depth of field and position of the light to simulate background problems. A reading solution that consistently reads under these conditions will lower installation cost and minimize bottleneck issues.

When determining your resolution requirements, the most important thing to consider is the number of pixels per module (PPM) you will need within your field of view. Higher resolution readers can maintain a high PPM for a larger field of view, allowing for more positional uncertainty. For very high speed applications, a standard resolution reader will generally provide faster performance. Some high resolution imagers, however, allow the application to use only part of the imager which can create even faster response times.

The **DataMan® 300** reader, for example, offers an intelligent tuning technology to automate the settings of the integrated lighting to find the optimal light setup for the part.

Lighting is especially important for DPM applications involving metals or other difficult-to-read materials. The proper lighting technique for dot peen applications, for example, can make or break a process. These marks are difficult to read unless lighting adjustments can be made. An intelligent tuning technology with controllable lighting is key for this application.

A reader that allows the user to change the lens offers greater adaptability for the reader to be deployed for different working distances based on the machine design requirements. Very often, the machine is designed long before a reader is considered, so having flexible optics in the reader makes retrofitting easier.

A powerful reader is of no use to the end user if it's too difficult to deploy and maintain.

3. Ease of Use

When readers are deployed, different parameters are set up to optimize the application. A step-by-step process should be intuitive for any floor personnel.

In addition, the reader must be able to communicate the results to another device, easily integrating into existing plant networks through whatever communications method is required: Ethernet, RS-232, etc. For establishing a communications link between a reader and a PC at the enterprise level, make sure the reader supports a broad range of standard network protocols, including: EtherNet/IP, PROFINET, MC Protocol and Modbus/TCP. This connection also gives you a centralized way of managing your readers, so be sure the ID reader you select will allow you to manage and control activity over the network from remote locations in the plant and beyond.

COGNEX CONNECT

Cognex Connect™ is a communications suite of Industrial Ethernet protocols that assures a seamless and reliable communications link between Cognex products and the factory network.

Having an easy to use setup tool minimizes the time it takes to integrate the reader and reduces the overall maintenance effort of the system.

Conclusion

DPM reading can be a very challenging application requiring technology and expertise solving difficult image analysis problems. Typically, companies experienced in industrial machine vision have the right expertise and technology for providing the highest DPM read rates. Your chosen vendor should also be able to provide the support necessary to thoroughly qualify your application, guide you through to installation success and have the financial stability to maintain their role as your DPM reading solutions provider for the long term.

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