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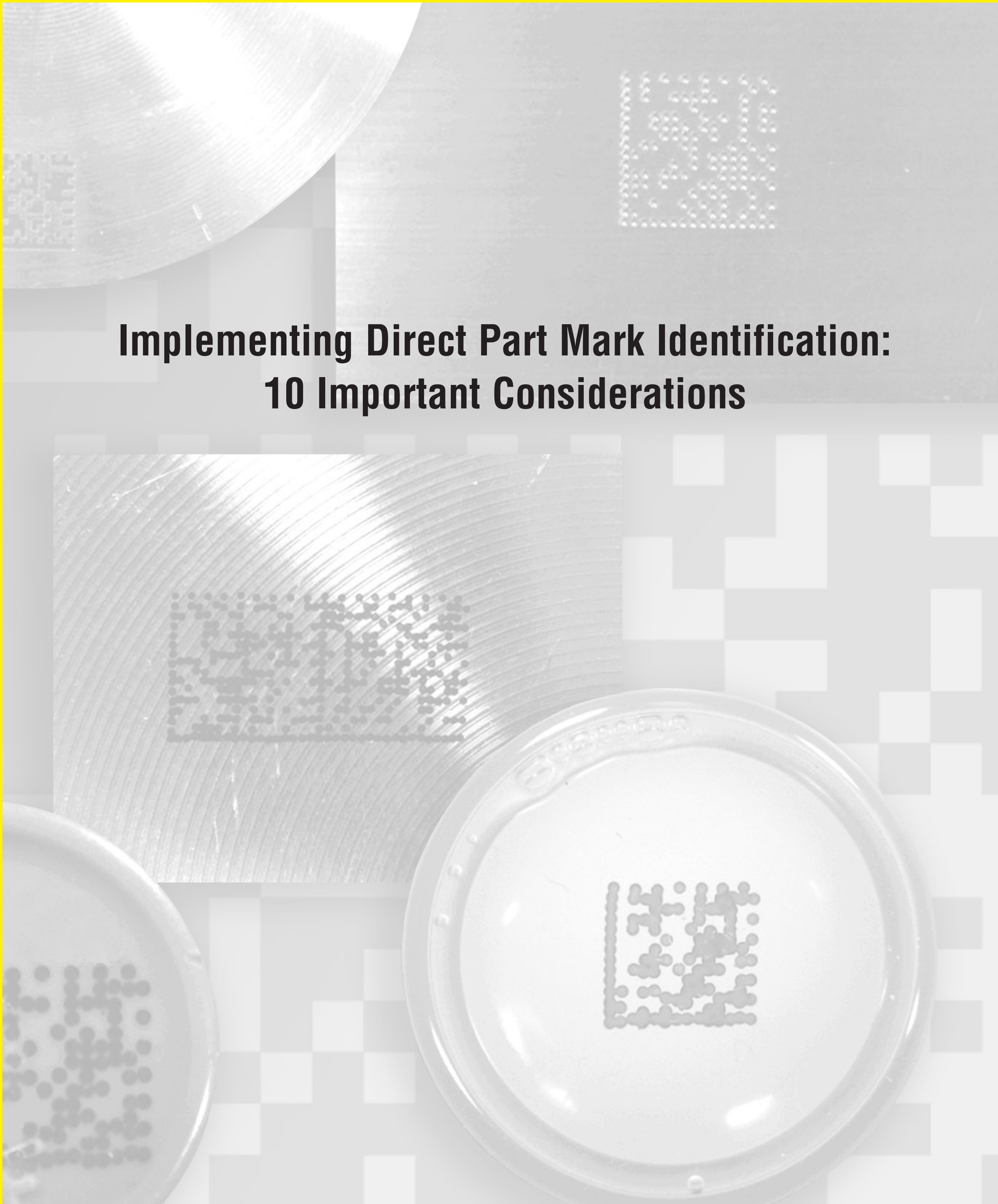
ID Products



Implementing Direct Part Mark Identification: 10 Important Considerations

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INTRODUCTION

Automatic identification of products using one-dimensional (1D) bar codes has been broadly used in many industries for more than 20 years. The part tracking data provided 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. Traditionally, these bar codes are applied to products with labels or as part of the product package.

Today there's a trend to extend tracking through the full life of a part so that it can be identified from the beginning of its life to the end. To address full life cycle traceability, manufacturers are marking parts with permanent two-dimensional (2D) codes that are marked directly on the part itself, and automatically identifying the part throughout the manufacturing and supply chain operations. This process is known as Direct Part Mark Identification (DPMI).

Assembly and parts suppliers to the Department of Defense are increasingly implementing DPMI, as are a growing number of automotive, aerospace, medical device and electronics manufacturers. Many manufacturers are using traceability data to create a history of the part through the manufacturing process for use later in supply chain management and repair depots.

Traceability also improves quality by ensuring that the appropriate processes are performed in the correct sequence on the right parts. DPMI is key in "error proofing" initiatives. In addition to eliminating manual part number data entry errors during production operations, DPMI can also assist in data logging for safety, liability, and warranty issues, and satisfy regulatory requirements for permanently identifying high-value parts that are subject to theft or counterfeiting.

Two-dimensional (2D) codes are used for DPMI applications due to their small size, error correction, and amount of data that can be stored as compared to 1D codes. These 2D codes are marked on the part using several methods depending upon the material composition, part application, and environmental conditions. Common methods include dot peening, laser, and electro-chemical etch.

Despite the fact that industries have adopted 2D code standards and formats to meet their process application needs, and marking technologies have advanced to provide the marking solutions required, high read rate DPMI has been difficult to achieve, limiting its use. These types of codes can be difficult to read due to low contrast, variations in part surfaces and partial damage due to process and environmental conditions.

Successful DPMI applications have required machine vision systems to provide the desired results. But due to advances in the power of digital signal processors, imaging sensors, and decoding algorithms, DPMI solutions are now available that are cost effective and deliver the reading results to achieve the objectives of the manufacturer.

Cognex ID Products can help ensure the success of your DPMI project. For additional information about selecting fixed-mount readers, hand-held readers, or code verifiers, please contact Cognex at (877) 264-6391, or visit www.cognex.com/2D.

1. Code Selection

Industry standards groups frequently define the appropriate code for a given application. For example, the Automotive Industry Action Group (AIAG) has published guidelines for Data Matrix™ and QR code; the Air Transport Association (ATA) as part of the Spec2000 bar code specification defines Data Matrix for DPMI; the U.S. Department of Defense (DoD) specifies Data Matrix for their unique identification (UID).

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, investigate the standards and guidelines set forth in other industries. This will allow you to define guidelines for your company on not only what code(s) to use but also recommendations on marking methods, data encoding and verification.

When there is no specified standard, Data Matrix ECC200 is recommended. This ANSI code standard is the most widely supported for DPMI applications involving metal, glass, ceramic, or plastic materials. Because this code is in the public domain, marking and reading equipment suppliers have invested significant R&D resources to improve the performance of ECC200 supporting equipment. As a result, there are more product choices, which generally results in higher performance and lower cost equipment, as compared to proprietary codes that lock you into a single supplier, or other code symbologies with fewer product offerings.

Industry Specification & Guidelines	
International Standards	
ISO/IEC 16022	Bar Code Symbology Specification – Data Matrix
ISO/IEC 15415	Bar Code Print Quality Test Specification – Two-Dimensional symbols
Automotive Industry Action Group (AIAG) Standards	
B-1	Bar Code Symbology Standard
B-4	Parts Identification and Tracking Application Standard
B-13	2D Symbology White Paper
B-14	Guidelines for use of Two-Dimensional Symbols with the B-10 Trading Partner Labels
B-17	2D Direct Parts Marking Guideline
U.S. Dept. of Defense (DoD) Standards	
MIL-STD-130	Identification Marking of U.S. Military Property
Air Transport Association (ATA) and International Aerospace Quality Group (IAQG) Standards	
ATA Spec 2000 Chapter 9	Automated Identification and Data Capture
AS9132	Data Matrix (2D) Coding Quality Requirements for Parts Marking
NASA Standards	
NASA-STD-6002	Applying Data Matrix Identification Symbols on Aerospace Parts
NASA-HDBK-6003	Application of Data Matrix Identification Symbols to Aerospace Parts Using Direct Part Marking Methods/Techniques
Electronics Industry Association (EIA)	
EIA 706	Component Marking
EIA 802	Product Marking

2. Data Encoding

The Data Matrix code offers a number of advantages for DPMI applications, including small size, high data encoding capacity, and error correction. Data encoding refers to the amount of information that is “stored” within the cell matrix when the Data Matrix code is generated. Code size can affect readability and is generally determined by the amount of data to be encoded, cell size, and surface roughness of the area on the part where the code will be applied. When trying to comply with an industry specification, an application specification will define the size that is needed in order to be in compliance.

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 and what code size to mark, one should also consider the amount of available real estate on the part. In some applications, the Data Matrix code is used as a “license plate” for the part, reducing the amount of data encoded and size of the code. In this case, a centralized database containing manufacturing and historical data referring to the part is updated as the part is identified during manufacturing and supply chain processes.

Other users take advantage of the large data capacity of the code and encode much more information about the part, creating what is referred to as a “portable database”. In most cases, whether one uses the code as a license plate or as a portable database is primarily determined by the goals of the application and the available space on the part.

Although Data Matrix supports a number of different formats and error correction methods that include: ECC 000, 050, 080, 100, 140 and 200, all industry standards and guidelines for DPMI applications are based on the ECC200 format of Data Matrix. It is highly recommended that any new application adopt this code format. There are 24 square formats and 6 rectangular formats available in ECC200. This provides the user the flexibility to encode anywhere between 6 and 3116 digits in a single code. It also supports advanced encoding and error checking capabilities that are based on what is known as Reed Solomon error correction. The Reed Solomon error correction capability allows a code to be successfully decoded even though as much as 60% of the code may be damaged.

Data Matrix ECC200 Square Formats			
Symbol Size*	Encoded		
Row x Column	Numbers	Characters	Bytes
10 x 10	6	3	1
12 x 12	10	6	3
14 x 14	16	10	6
16 x 16	24	16	10
18 x 18	36	25	16
20 x 20	44	31	20
22 x 22	60	43	28
24 x 24	72	52	34
26 x 26	88	64	42
32 x 32	124	91	60
36 x 36	172	127	84
40 x 40	228	169	112
44 x 44	288	214	142
48 x 48	348	259	172

* Symbol size can be as large as 144 x 144

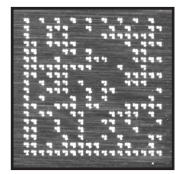
Data Matrix ECC200 Rectangular Formats			
Symbol Size	Encoded		
Row x Column	Numbers	Characters	Bytes
8 x 18	10	6	3
8 x 32	20	13	8
12 x 26	32	22	14
12 x 36	44	31	20
16 x 36	64	46	30

3. Marking Methods

The primary methods used to produce machine-readable symbols for DPMI include dot peening, laser marking, chemical etching, and ink-jet printing. Important factors influencing the marking method decision include 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 and location of the mark on the part.

Full life cycle traceability requires that the mark be permanent, which means that the mark must last for the expected life of the item. Mark permanence, however, is a relative term that can vary by industry because different industries generally apply their own yardsticks when defining product life cycles. While the aerospace industry may consider the expected life of an aircraft part to be 25 years or longer, the semiconductor or telecom industries may view a given component's life cycle as only five years.

Dot peening is achieved by striking a carbide or diamond tipped marker stylus against the surface of the material being marked. Dot peening has the advantages of being inexpensive, requiring no consumables, and producing very permanent marks that are not affected by heat. However, dot peening requires continued maintenance due to stylus wear and movement. In addition, dot peening produces marks with varying degrees of contrast, challenging the reading systems to yield high read rates. Dot peening is widely used in the automotive and aerospace industries due to the demanding life cycle requirements of these industries.



Dot Peen

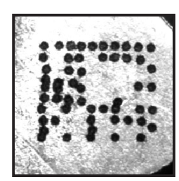
Laser marking applies heat to the surface that causes substrate surface melting in order to produce a mark. Laser marking offers several advantages including high speed and high precision. This method is very good for marking small 2D codes with high densities (large data capacity). Laser markers are typically higher in cost than other marking methods. Lasers produce low contrast marks on some materials, and in some cases, lasers cannot mark on certain materials, limiting application flexibility. Laser marking is widely used in the semiconductor, electronics and medical device industries.

Laser

Electro-chemical etching (ECE) is very cost effective, but it's difficult to apply in high volume-manufacturing environments. ECE is recommended for round surfaces or for stress sensitive parts, but has the drawback of requiring replenishment of consumables. In addition, marks are typically very low contrast, and the parts must be tightly secured while marking. ECE is used for marking certain components used in jet engine, automotive, and medical device manufacturing.

Electro-Chemical Etch

Ink-jet printers propel ink droplets from the printing head to the part surface. Ink-jet marking provides fast marking of moving parts, and offers very good contrast. Ink-jet markers require regular maintenance when the jets clog, and require replenishment of costly consumables such as ink and solvents. Ink-jet marking is not considered permanent in many DPMI applications.



Ink-Jet

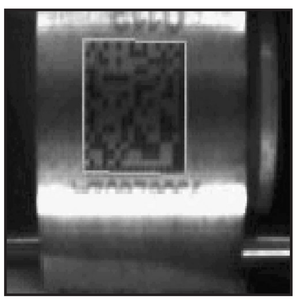
4. Mark Placement

Choosing the location for the code on the part can directly impact the readability of the code. The location should be clearly visible throughout the manufacturing process and it is best to mark on a flat site on the part. Also, choose a location where the mark is in a prominent position on the part that is easily viewed by the reader. Avoid locations where there may be a surrounding surface relief that could potentially affect the illumination of the code by the reader's illumination source.

Wherever possible, it is best to provide a "clear zone" around the mark where no features, part edges, noise, or other interference comes into contact with the code itself.

In those cases where the mark must be placed on a cylindrical part, care must be taken in selecting the size of the code. Surface curvature can create distortions to the code and make proper illumination of the code very difficult. In order to mitigate this problem, a code size that is no larger than 16% of the diameter or 5% of the circumference of the part is recommended.

In those cases where it is impossible to accommodate these considerations, work with the reader vendor on how to effectively image and read your marks. Make sure to work with a vendor that has the product offerings to address "non-standard" DPMI applications.



Mark on Curved Surface

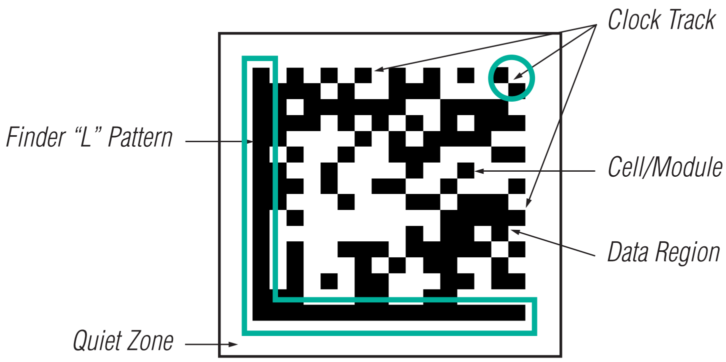
Small Code with Low Resolution

5. Readability

Readability is a term used to define how easy or difficult it is for a reader to successfully read a code. DPMI is rapidly becoming a required part of the manufacturing process, so if a code is not read, the part is not processed, or the production line stops. Until recently, manufacturers implementing DPMI have lived with varying levels of read rates, in some cases approaching the upper 90% level; however, this level of performance is no longer acceptable. DPMI solution providers must demonstrate that they can achieve six sigma read rates, a vision of quality which equates with only 3.4 defects per million opportunities. To achieve this read rate it is important to plan, understand and implement a marking process that will produce these results.

A user looking to implement DPMI must understand all of the factors that affect the readability of the code. A good baseline for this is to understand the design of the Data Matrix symbology and associated issues that might impact readability.

The features that comprise the Data Matrix symbol are the quiet zone, the finder pattern, the clocking pattern, and the data region. Each individual element is referred to as a cell or module. The actual appearance of the code depends on the type of mark placed. For example, a Data Matrix code formed with a laser marking machine or printer would appear with a "continuous L pattern" and square cells; whereas, dot peen and ink-jet markers produce codes that have a "non-continuous L pattern", with a data pattern made up of round cells.



The quiet zone, or QZ, is a clear area free of all other markings that surrounds the symbol on all four sides. For a Data Matrix code marked with a continuous L pattern, the QZ width should equal the width of at least one cell. Codes that are formed by dots should have a QZ equal to the width of at least four cells. This is important because defects within the QZ make it more difficult for the decoding algorithms to locate the symbol within the image, and adversely impact readability.

The finder pattern consists of two orthogonal lines, known as the "L pattern". The L pattern is the key feature for the reader to use to locate the position of the code in the field of view. For highest readability throughout the life cycle of the part, it is important to start with a high quality finder pattern. The traits determining finder pattern quality vary, depending on how the code is formed. Codes formed with square cells should have a continuous L pattern, and should not have breaks in the lines. For codes formed by dots, every dot must be present, distinct, disconnected, and well formed. Successful location of the code within an image is the first step in successful reading.

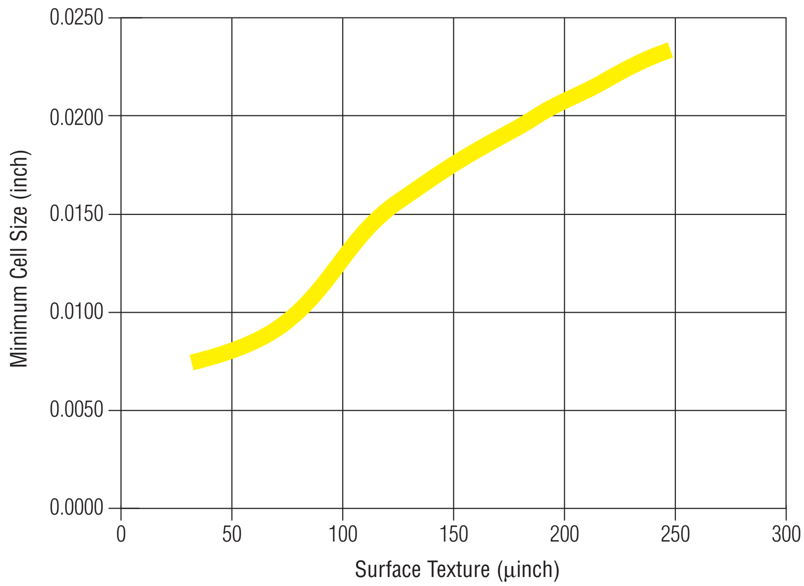
Once a code has been successfully found in the image, the next step is determining which cells are light and which cells are dark. At the opposite sides of the finder pattern, along the perimeter, there are alternating dark and light cells known as the clocking pattern. The clocking pattern defines the configuration of the pattern of light and dark cells that make up the data region of Data Matrix code. In the ideal case, each light and dark cell of the clocking pattern and data region would be of equal size. In order to achieve high readability it is important that the DPMI reader can distinguish between light and dark cells.

A code pattern with individual cells that are consistent in shape and size, and cells that are distinctively different in shape and size from other features on the surface of the part provide the basis for robust and reliable code location and reading. However, in DMPI applications this can be challenging due to variations in the surface texture, variations in part presentation during the marking process, and inherent variability of the marking machine. For example, the bumps on the surface of a cast part will show up in an image. If these bumps 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.

For robust and reliable reading, cell size must be significantly larger than the grain, bumps, texture or other patterns on the surface of the part. Minimum cell size (MCS) refers to the smallest recommended cell size for a particular part or application. The International Aerospace Quality Group provides the following guidelines to help determine the minimum cell size required in relation to the roughness of the surface.

An objective verification of the code at the marking machine will help assure that the Data Matrix mark that is produced meets the specifications of the standards, and greatly contributes to readability success downstream.

Recommended Cell Size for a Given Surface Texture



6. Verification

In order to assure that the marking equipment is applying a mark that will meet the requirements for achieving the highest read rates, it is highly recommended that a code verification system be implemented at the marking station. This is not only a critical factor for downstream reading performance, but it reduces costs associated with rejected parts due to unreadable codes. If a part loses its identity due to the quality of the mark, then the part cannot be used. A verification system will immediately detect a problem with the marking machine which could be due to poor fixturing of the part, damage to the machine such as a broken tip on a dot peen machine, or incorrect settings during part changeover.

Additionally, a code verification system can also provide process feedback on the marking machine that can be used in preventive maintenance. For example, the verifier can monitor the wear of the tip on a dot peen machine by monitoring dot size and flag the operator on the floor when a pin should be changed.

A code verifier is a system that includes lighting, optics, camera, Data Matrix verification software, and calibration. A verification system for DPMI needs to be defined for each application due to the various types of materials, surface conditions, and marks. Lighting and optics should be configured to ensure an optimal image formation that delivers good contrast with adequate resolution. In order to have meaningful verification results it is recommended that the resolution at the verification station be at least twice that of the reading station resolution. This can be accomplished with either higher magnification optics or a higher resolution camera. Another important step in generating consistent and meaningful results is consistent part presentation. Lastly, a calibration step needs to be implemented in order to provide a method of establishing a baseline for the lighting, optics and resolution.

There are several verification standards in use today. The verification standard selected depends on the industry application, type of mark, and marking method used. For example, for codes that are printed with square cells (i.e. paper or laser marking), AIM Verification standards are appropriate. AIM Verification standards, which are part of the Data Matrix specifications, measure print contrast, modulation, axial non-uniformity, and unused error correction to grade marks on an A-F scale where A is excellent and F is fail.

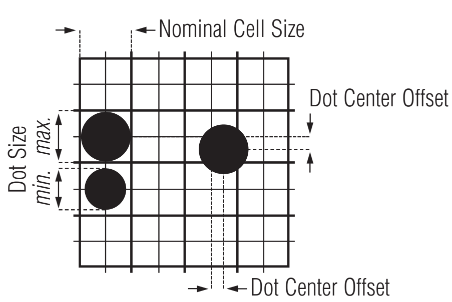
The quality metrics when using the AIM standard as a basis for verification are defined in Section 8 and Annex N of the *International Symbology Specification – Data Matrix* (ISO 16022). When using the AIM standard, each of the quality metrics that are defined in the table below yield a "grade" of A (4.0) through F (0.0). The overall quality of a symbol is the lowest grade achieved by any of the tests.

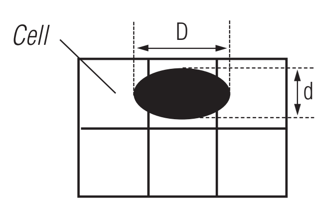
Quality Metrics Defined by AIM Standard

Aim Verification Test	Symbol Decode	Symbol Contrast	"Print" Growth	"Axial" Non-uniformity	Unused Error Correction
Description	Test whether the symbol was decodable. If not, no additional information is returned	Compares the contrast between the darkest 10% & the lightest 10% of the pixels within the code	Checks the extent to which dark & light markings appropriately fill their module boundaries	Is a measure of how much the spacing between cells differs from one axis to another	Tests the extent to which damage to the code has eroded the reading safety margin that error correction provides
Results	"A"= Successful decode "F"= Failed to decode	"A" if >= 70% "B" if >= 55% "C" if >= 40% "D" if >= 20% "F" if < 20%	"A" if >= -0.50 and <= 0.50 "B" if >= -0.70 and <= 0.70 "C" if >= -0.85 and <= 0.85 "D" if >= -1.00 and <= 1.00 "F" if < -1.00 or > 1.00	"A" if <= 0.06 "B" if <= 0.08 "C" if <= 0.10 "D" if <= 0.12 "F" if < 0.12	"A" if UEC >= 0.62 "B" if UEC >= 0.50 "C" if UEC >= 0.37 "D" if UEC >= 0.25 "F" if UEC < 0.25

The IAQG Verification standard is the best standard for marks produced by dot peening. IAQG measures dot size, dot position, and dot ovality to give each mark a grade of A, B or F, which indicates whether a mark is excellent, acceptable, or fails, respectively. The basis for this verification standard is defined in IAQG (International Aerospace Quality Group) standard 9132. When using the IAQG metrics, each dot is analyzed and assigned a grade of A (4.0) through F (0.0). The overall quality of a symbol is the lowest grade achieved by any of the tests.

Quality	Excellent	Acceptable
Dot Size (% of the Nominal Cell Size)	70 to 90%	60 to 100%
Dot Center Offset (% of the nominal cell size)	0 to 10%	10 to 20%
Angle of Distortion	±3.5°	±7°





Definition of Ovality
D-d <= 20% of the Cell Size

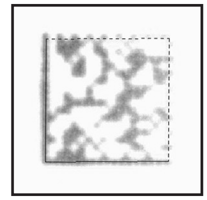
7. Selecting a reader

The process of evaluating and selecting a reader is critical to the success of the overall DPMI application. There are many factors that go into the selection process of any new equipment, but in the case of a DPMI reader, there is none more important than the read rate. The capability of the reader to consistently read codes throughout the process is critical.

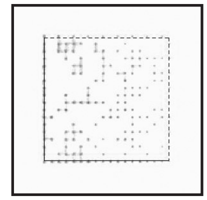
As has been previously discussed, there are many variables that impact the quality of the code. Verification of the code at the marking station helps eliminate reading problems caused by missing or inconsistent features of the code. However, in DPMI applications distortions to the code are quite common due to part material composition, variations in part presentation, or variability caused by the manufacturing process. It is important to select a reader that can tolerate a wide range of distortions to the appearance of the code no matter what the cause.

A set of sample parts that are representative of the range of mark quality that a reader will need to handle should serve as the basis for a preliminary test of a reader's read rate. However, a more extensive pilot test is recommended so that more read rate statistics can be gathered and analyzed.

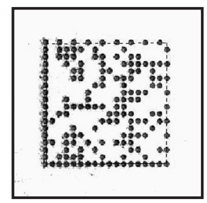
In addition to read rate, it is important that the reader return a result quickly. This is true no matter what type of DPMI reader is used. In operations requiring hand-held or presentation DPMI readers, accurate and fast decoding is important. Although the main driver for the use of an automatic reader is to eliminate data accuracy errors, the implementation of the readers cannot slow down the process. Due to the difficult challenges of DPMI reading, many hand-held readers are very slow in their decoding time, oftentimes resulting in a no read. This leads to frustration on the part of the operator, and ultimately lack of use and wasted investment.



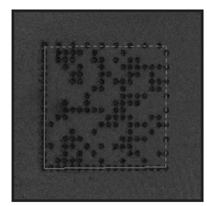
Poor Focus



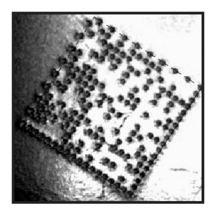
Washed Out



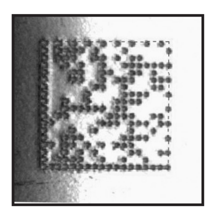
Model Image



Low Contrast



Finder Degradation



Background Problems

8. Types of DPMI readers

There are three types of reader (decoder) products for DPMI in general use today: fixed-mount readers, presentation readers, and hand-held readers.

Fixed-mount Reader

Fixed-mount readers are used in identifying parts that are handled and moved automatically by conveyor, indexer, or robot. Typically, fully automated manufacturing lines such as those found in electronics and automotive manufacturing use fixed-mount readers.

In operation, this type of reader is mounted in a fixed position where the mark can repeatably be placed in front of the reader in either continuous or indexed motion. The reader is signaled that the part is ready for reading by a “trigger”. This trigger event is performed by an external sensor that detects the presence of the part or by an encoder that knows the position of the part at all times and can signal the reader to decode.

Fixed-mount readers are configured with either an integrated light source or with an external light source as required by the application. Advantages of a fixed-mount reader without an integrated light source are that it can be mounted in varying working distances from the part and supplemental lighting can be selected to meet the application needs.

It is advantageous to use fixed-mount readers that can be easily set-up, viewed and maintained over an Ethernet network for efficiency. Frequently, fixed-mount readers are part of a network of general-purpose machine vision sensors performing other inspection and gauging tasks, and must communicate over an Ethernet network to the general manufacturing control system.

Hand-held Reader

Similar to a fixed-mount reader, a presentation reader is a reader that is mounted in a fixed position; however, it operates in a continuous reading cycle, automatically performing the decoding task once the operator places the part in front of the reader. Presentation readers can provide a very fast way of reading part codes in areas where parts are handled manually. A presentation reader can be implemented with either a fixed-mount reader or hand-held reader. Using a hand-held reader in presentation mode provides the opportunity for multi-use – as one can also remove the reader from its stand and bring it to the part.

Hand-held readers are preferred in those environments where part handling is not automated or parts vary greatly in size. Hand-helds are used in job shop manufacturing operations, QC test stations, and in logistics areas. Hand-held readers come in either tethered (with a cord), or cordless configurations. Tethered hand-held readers have the advantage of not being displaced from the application location. Cordless operation is required in cases where part size or position are a practical limitation to cord length.

9. Connectivity/IO

Connectivity refers to the method of interfacing the reader or verifier to a controller such as a PLC or PC so that the result of the decoding is communicated. The connectivity method depends upon the application and the type of reader involved.

In fixed-mount DPMI applications read results are usually sent to process equipment or to a database over the factory network, so the DPMI reader should offer both serial and network communications. Serial communications are used typically in applications where the read or verification results stay "local" to the work cell or factory automation equipment. Network connectivity enables the reader to communicate decoded results data to PCs and databases at the enterprise level. 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:

Common Industrial Communication Protocols used in DPMI Applications	
SMTP	SMTP (Simple Main Transfer Protocol) capability enables e-notification of problems that occur on the production line.
FTP	FTP (File Transfer Protocol) enables users to easily archive failed inspection images without writing custom software.
DHCP	With DHCP (Dynamic Host Configuration Protocol), each reader you link to the network is automatically assigned an IP address, enabling true plug-and-play performance.
DNS	This allows you to name each reader, such as "ID Reader Line 1", instead of having to rely on a 9-digit IP address.
TCP/IP client server	Look for readers with TCP/IP client server capability, as they are able to send results to other devices directly over Ethernet without any code development.
Telnet	An internet standard protocol that enables remote login and connection from host devices.
EtherNet/IP	This protocol enables readers to be linked to PLCs and other devices over a single Ethernet cable, eliminating the need for complex wiring schemes and costly network gateways.
ModBus/TCP	Another factory network protocol that permits direct connectivity to other devices over Ethernet.

Finally, as more and more ID readers are used throughout the manufacturing process, it becomes important to have a centralized way of managing them. Make sure the ID Reader will allow you to manage and control vision activity over the network from remote locations in the plant and beyond.

In the case of hand-held readers, connectivity methods depend on whether the reader is tethered (uses a cord) or cordless. Tethered readers often communicate the read result through what is called a "keyboard wedge" interface, which emulates the keystrokes of a keyboard making integration to a PC very simple. Alternatively, communications can be made over an RS232-C interface. A cordless hand-held reader uses wireless technology, such as Bluetooth®, in order to communicate to the base PC station or other controller.

10. Vendor Selection

Success in implementing a DPMI application depends upon many factors that have been outlined in this document. DPMI is a very challenging application requiring technology and know-how in solving difficult image analysis problems. Typically, companies experienced in industrial machine vision have the right know-how and technology for providing the highest DPMI read rates. Core competencies in image formation, image processing, and image analysis, give companies with machine vision background a significant edge in delivering DPMI solutions that really work. This machine vision foundation is now being brought to the market in new generations of DPMI products that pack the same power as traditional machine vision systems used in many applications in factories today. Suppliers of more traditional Auto-ID products lack the experience and know-how that comes from analyzing millions of images each year in real world conditions; as a result the ID readers coming from these companies will not succeed in delivering high read rates in DPMI applications.

The vendor should provide the support necessary to thoroughly qualify your DPMI application, guide you through the considerations in assuring success, and insure that the installation is a success.

It is also important to look for a vendor with a global network of offices offering both pre- and post-sales support. This way, you can get the same consistent high level of product support anywhere in the world. This can be especially important if the system is commissioned in one location and shipped to another.

And finally, the selected supplier should have a successful track record and financial stability to maintain their role as your DPMI reading solutions provider for the long term.

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