Direct Part Mark Identification and Verification

Machine readable identification holds the key to manufacturing efficiency

Machine readable identification is fast becoming a trend throughout many industry sectors and is used to automatically identify a variety of products. Manufacturers are marking parts with machine-readable, permanent two-dimensional (2D) codes that are placed directly on the part itself. Then the part can be tracked throughout its entire life cycle, including manufacturing and supply chain operations. This is called Direct Part Mark Identification (DPMI) or Auto-ID. The Electronics Industry Association (EIA), Automotive Industry Action Group (AIAG), Department of Defense (DOD), Air Transport Association (ATA) and International Aerospace Quality Group (IAQG) have adopted DPMI standards for applications in their industries.

DPMI enables many tangible benefits for manufacturers. This practice:

- Improves manufacturing process performance
- Identifies quality defects, through in-service tracking
- Eliminates manual part data entry errors
- Supports data logging and automated data collection
- Increase yields, and
- As a result, reduces the direct and indirect costs of manufacturing.

Many manufacturers rely on Auto-ID as well to track high-value parts to prevent theft or counterfeiting, identify parts for maintenance and returns, and to resolve warranty issues and liability claims.

Two-dimensional symbols such as Data Matrix are the most common symbologies used for DPMI due to their small size, data capacity, and error correction, plus their ability to be produced by a variety of marking methods. Common methods to apply 2D codes are dot peening, laser and electro-chemical etch. The two-dimensional 2D Data Matrix code consists of an arrangement of small dots or squares, marked as either a square or rectangle (Figures 1 and 2).

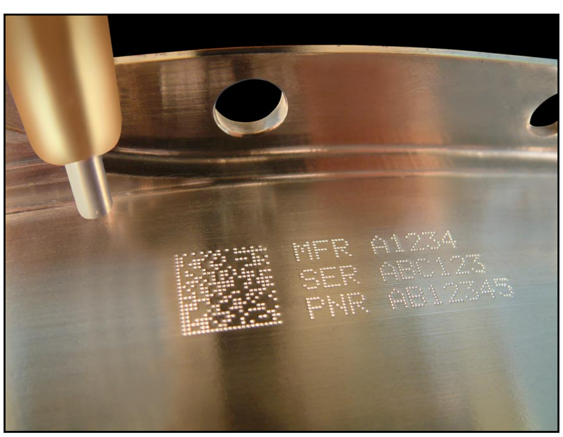

Figure 1

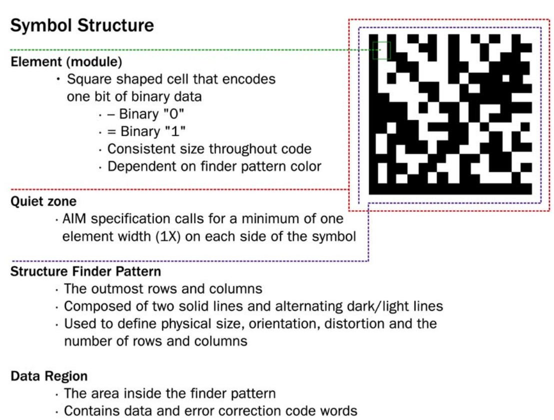

Figure 2

Why Verify 2D Symbols?

To ensure consistent, high quality 2D Data Matrix symbols marked directly on parts, many automotive and aerospace companies such as Delphi, General Motors, Pratt Whitney, GE Aircraft Engines, and Raytheon immediately verify the code following the marking operation. Verification is a method that objectively determines the quality of the mark based upon a comparison of a direct part mark to an established specification or standard. The goal of verification is to ensure that the code is marked to the highest possible degree of quality.

If manufacturers are to realize the benefits of direct part marking identification, it is essential that the marking equipment apply a mark that will deliver the highest read rates within a part's lifecycle. Verification enables part suppliers to meet the demands of supply contracts (such as found in DOD) requiring direct part marking on parts and assemblies. If the 2D code is not readable at every desired step *downstream* throughout the manufacturing or supply chain operations, manufacturing errors, scrap or downtime caused by unreadable codes may result.

Verification is also used to monitor the performance of the direct part marking equipment. A verification system will immediately report a problem with the marking machine which could be caused by:

- Poor fixturing of the part
- Damage to the dot peen machine such as a worn or broken stylus tip
- Surface changes in the material being marked or
- Incorrect machine settings after part changeover.

What is a Verification System?

A 2D Data Matrix verifier is a system that includes a fixed station camera, optics, lighting, part fixtures, and Data Matrix verification software tools. As marking requirements are as individual as the end products themselves due to the wide range of materials and surface conditions that are marked, a DPMI verification system should be defined for each application. The desired result is a controlled and repeatable set-up of camera/verifier, optics and lighting that takes into account:

- The set-up of the lighting
- The specified standoff distance of the symbol from the camera
- The specified lens/aperture/focus settings of the camera
- The part fixtures

Typically, a smart camera with embedded verification software reads the symbol and compares the symbol to the appropriate specification. A report is produced on every parameter in the specification and an overall grade based on the results is given. Verification cares about surface color, surface finish, and marking techniques.

Figure 3

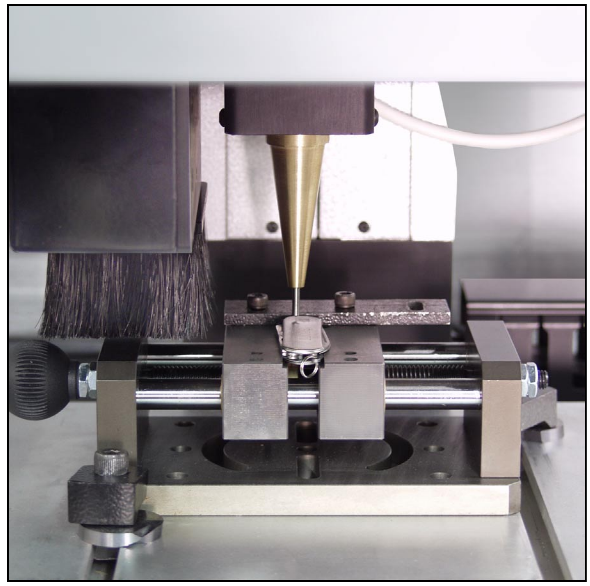

Figure 4

The camera can be mounted either on the marking equipment (in-line) or nearby the marking equipment as a separate off-line system. Figures 3 and 4 show an in-line Mark to Verify System with the camera mounted directly on the marking head. Immediately following the marking cycle, the marking head positions the camera verifier directly over the mark (Figure 5) at a specified focal length and under a controlled lighting environment. The mark's conformance to the specification is then communicated to the operator as either pass or fail (Figures 6 and 7).

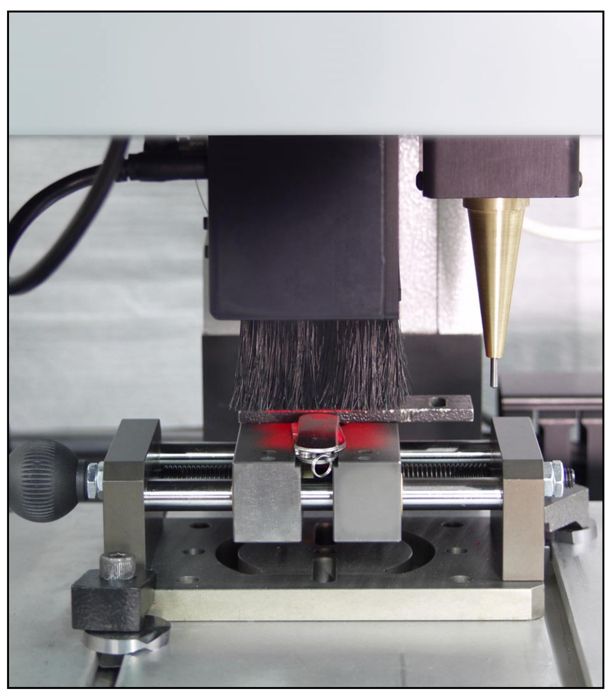

Figure 5

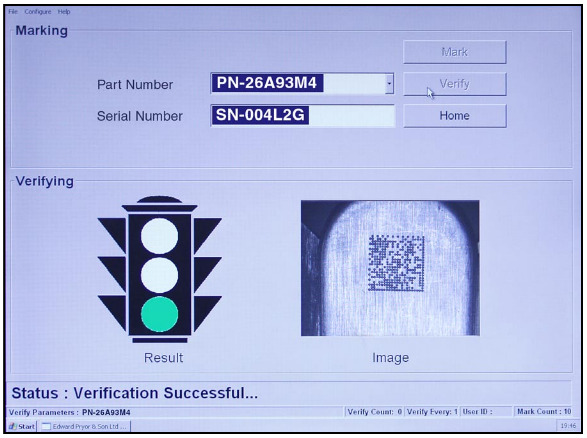

Figure 6

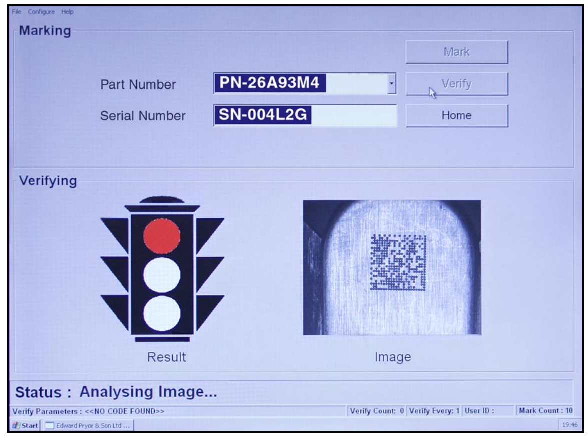

Figure 7

When the code quality begins to deteriorate, the verification system can signal an operator that the marking process is drifting out of control. Corrective adjustments can be made or preventive maintenance can be performed immediately, before production is impacted and scrap parts are produced (Figure 8).

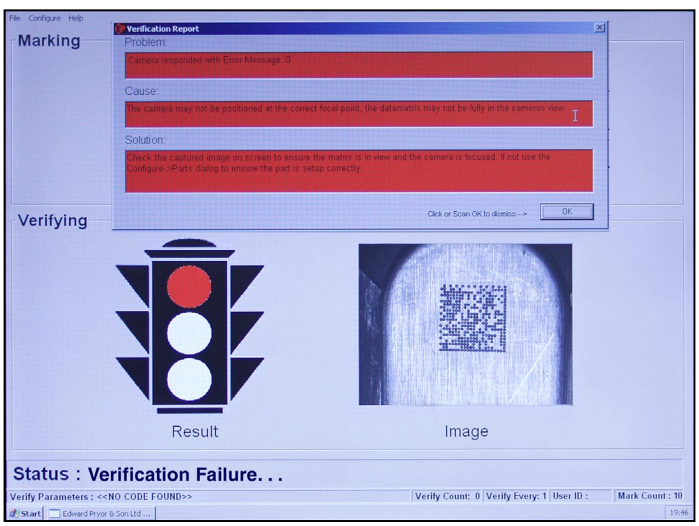

Figure 8

The optimum configuration for a direct part mark verifier is typically different than that for a reader. Direct part mark verification requires higher camera resolution than for reading (more pixels per Data Matrix cell). For this reason, fixed station cameras/verifiers, generally with internal lighting, are used. Meaningful verification results can only be generated by consistent and repeatable part presentation of the mark to the verifier, with the axis of the camera generally perpendicular to the mark surface. Also critical to proper verification is a consistent, uniform lighting environment on the part. For low contrast marks, supplemental lighting is often the key to successful verification results. Verification is a built-in software feature found in fixed station 2D Data Matrix readers produced by Cognex, Microscan, RVSI and others.

Readable marks generally result when the symbol itself is sufficiently differentiated from the part surface, in color/contrast and texture/roughness. However, verification does not guarantee that a reader will read the mark. Metal removal operations, heat treatment, painting, and part coatings such as rust inhibitors may degrade the mark such that it is unreadable downstream of the marking operation.

Verification uses a set of quality measures developed specifically for direct part marking identification (DPMI). Several verification standards are used today. Established industry specifications and guidelines are listed in Table 1 at the end of this article. For 2D symbols produced by dot peen marking, International Aerospace Quality Group (IAQG) 9132 is an aerospace industry standard that specifies uniform technical and quality requirements for dot peen marks on metal.

It defines how large the dots need to be in relation to the surface texture. IAQG quality metrics measure the following parameters to determine if a 2D mark is acceptable and assigns a grade based upon four factors:

- Dot size
- Dot position or dot center offset
- Uniformity or angle of distortion
- Dot ovality or roundness

The grades are A (excellent), B (acceptable) or F (failure) for each parameter. The overall grade is assigned based upon the lowest parameter grading.

Benefits of 2D Symbol Verification

Verification takes the guesswork out of maintaining consistently high mark quality. It also maintains conformance to the appropriate standard, which should improve reading/decoding capability later in production, as the mark may deteriorate. Full verification can be implemented at each marking station to guarantee good initial mark quality, thus assuring readability or decoding of the mark at any follow-on production steps, either at your own site or at your customer's facilities.

Full direct part mark verification allows manufacturers to continuously monitor and adjust their marking system before it begins producing unreadable marks. Direct part mark quality problems that can be detected by verification technology include:

- Improper or inconsistent mark dot size
- Improper or inconsistent mark dot location
- Improper overall mark geometry
- Mark or part surface damage

Verification is an excellent real time quality control method to keep the marking operation in control and to standard, thus helping manufacturers improve their processes through direct part marking.

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Table 1:

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