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Superseding AS9132A

(R) Data Matrix Quality Requirements for Parts Marking

RATIONALE

This standard has been revised to cleanup the general text/content and reformat the document to the latest format/style guide. This standard was created to provide for uniform quality and technical requirements relative to metallic parts marking performed within the aviation, space, and defense industry. This standard can be invoked as a stand-alone requirement or used in conjunction with 9100-series standards (i.e., 9100, 9110, 9120).

AS9132B has been reaffirmed to comply with the SAE Five-Year Review policy.

FOREWORD

To assure customer satisfaction, the aviation, space, and defense industry organizations must produce and continually improve safe, reliable products that meet or exceed customer and regulatory authority requirements. The globalization of the industry, and the resulting diversity of regional/national requirements and expectations, has complicated this objective. End-product organizations face the challenge of assuring the quality of, and integrating, product purchased from suppliers throughout the world and at all levels within the supply chain. Furthermore, suppliers and processors, within the industry, face the challenge of delivering product to multiple customers having varying quality expectations and requirements.

The aviation, space, and defense industry established the International Aerospace Quality Group (IAQG) for the purpose of achieving significant improvements in quality and safety, and reductions in cost, throughout the value stream. This organization includes representation from companies in the Americas, Asia/Pacific, and Europe. This document standardizes data matrix quality requirements for parts marking for the industry. The establishment of common requirements, for use at all levels of the supply-chain by organizations, should result in improved quality and safety, and decreased costs, due to the elimination or reduction of organization-unique requirements and the resultant variation inherent in these multiple expectations.

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1. SCOPE

This standard defines uniform quality and technical requirements relative to metallic parts marking performed using "data matrix symbology" within the aviation, space, and defense industry. ISO/IEC 16022 specifies general requirements (e.g., data character encodation, error correction rules, decoding algorithm). In addition to ISO/IEC 16022 specification, part identification with such symbology is subject to the requirements in this standard to ensure electronic reading of the symbol.

The marking processes covered by this standard are as follows:

- Dot Peening
- Laser
- Electro-Chemical Etching

Further marking processes will be included, if required.

Unless specified otherwise in the contractual business relationship, the company responsible for the design of the part shall determine the location of the data matrix marking. Symbol position should allow optimum illumination from all sides for readability.

This standard does not specify information to be encoded.

1.1 Convention

The following conventions are used in this standard:

- The word "shall" indicates mandatory requirements.
- The word "should" indicates requirements with some flexibility allowed in compliance methodology. Producers choosing other approaches to satisfy a "should" shall be able to show that their approach meets the intent of the standard's requirement.
- The words "typical", "example", "for reference" or "e.g." indicate suggestions given for guidance only.
- Appendices to this document are for information only and are provided for use as guidelines.
- Dimensions used in this document are as follows. Metric millimeter (mm) sizes followed by inches (in) in parentheses, unless otherwise stated.

2. REFERENCES

The following documents support the application/use of this standard. When a conflict in requirements between this standard and the referenced documents exist, the requirements of this document shall take precedence.

9102 Aerospace First Article Inspection Requirement

ISO/IEC 16022 Information technology – Automatic identification and data capture techniques – Data Matrix bar code symbology specification

3. MARKING REQUIREMENTS

3.1 General Requirements

a. Rows and Columns:

Rows and columns connected with data matrix symbology shall conform to Error Checking and Correcting (ECC) 200 (see ISO/IEC 16022).

b. Square versus Rectangle:

Matrix may be square or rectangular within ECC200 requirements (see ISO/IEC 16022). Square is preferred for easier reading.

c. Quiet Zone:

The quiet zone (margin) around the matrix shall be equal to or greater than one module size.

d. Round Surface:

If the marking is made on a round/curved surface, the symbol coverage shall be equal to or less than 16% of the diameter or 5% of circumference.

e. Symbol Size:

To facilitate electronic reading of the symbol, the overall symbol size should be less than 25.4 mm (1.000 inch), outside dimension, longest side. Irrespective of matrix size used, the requirements included in this standard shall be applied.

f. Angular Distortion of the Symbol:

Angular deviation of 90-degree axes between row and column shall not exceed ± 7 degrees (see Figure 1).

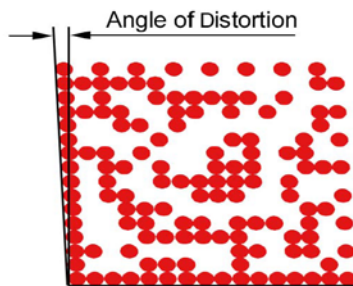


Figure 1 - Angle of distortion

3.2 Dot Peening

3.2.1 Description of Process

- a. Dot-peen marking technology typically produces round indentations on a part's surface with a pneumatically or electromechanically driven pin, otherwise known as a stylus. Critical to the readability of dot-peen marked symbols are the indented dot's shape, size, and spacing. The dot size and appearance are determined mostly by the stylus cone angle, marking force, and material hardness. The indented dot created should be suitable to trap or reflect light and large enough to be distinguishable from the parts surface roughness. It should also have spacing wide enough to accommodate varying module sizes, placement, and illumination (see Figure 2).

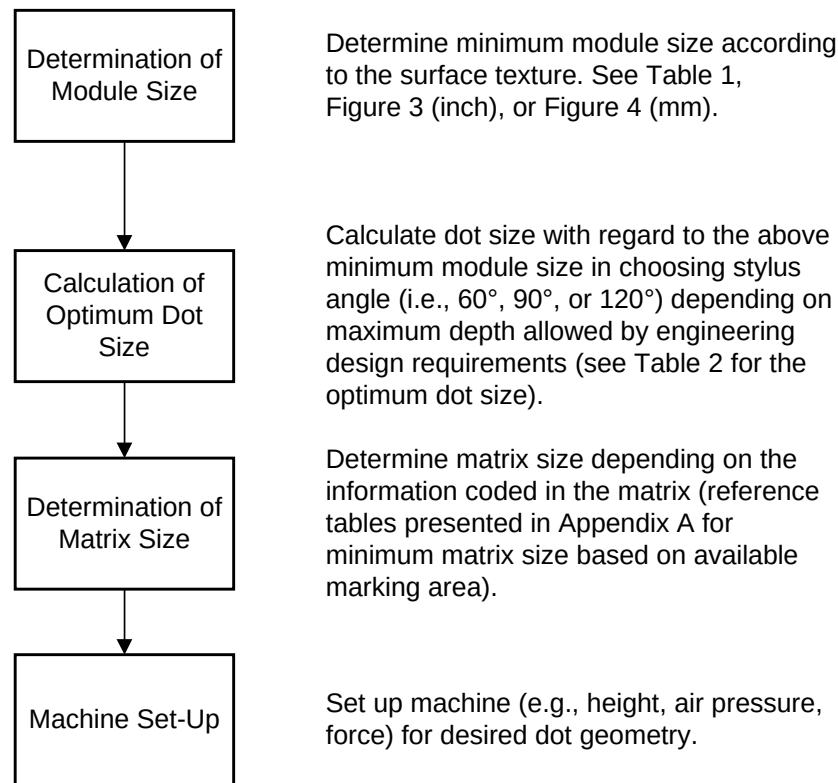


Figure 2 - Instructions for determination of marking parameters

- b. The issues involved in marking and reading dot-peen-marked symbols on metals are different than symbols printed on paper. The first fundamental difference is that the contrast between dark and light fields is created by artificial illumination of the symbol. Therefore, the module's shape, size, spacing, and part surface finish can all affect symbol readability.
- c. The key to a successful dot-peen marking and reading project is to control the variables affecting the consistency of the process. Symbol reading verification systems can provide feedback of the process parameters to some extent. Marking system operating and maintenance procedures shall be established to help ensure consistent symbol quality. Regular maintenance schedules should be established to check for issues such as stylus wear.
- d. Additional processes, like machining dedicated surfaces, may be necessary to improve the symbol readability. Cleaning the part surfaces, prior to marking, with an abrasive pad to remove coatings, rust, and discoloration, or using an air knife to blow away excess machining fluids, debris, or oil can increase the symbol readability.

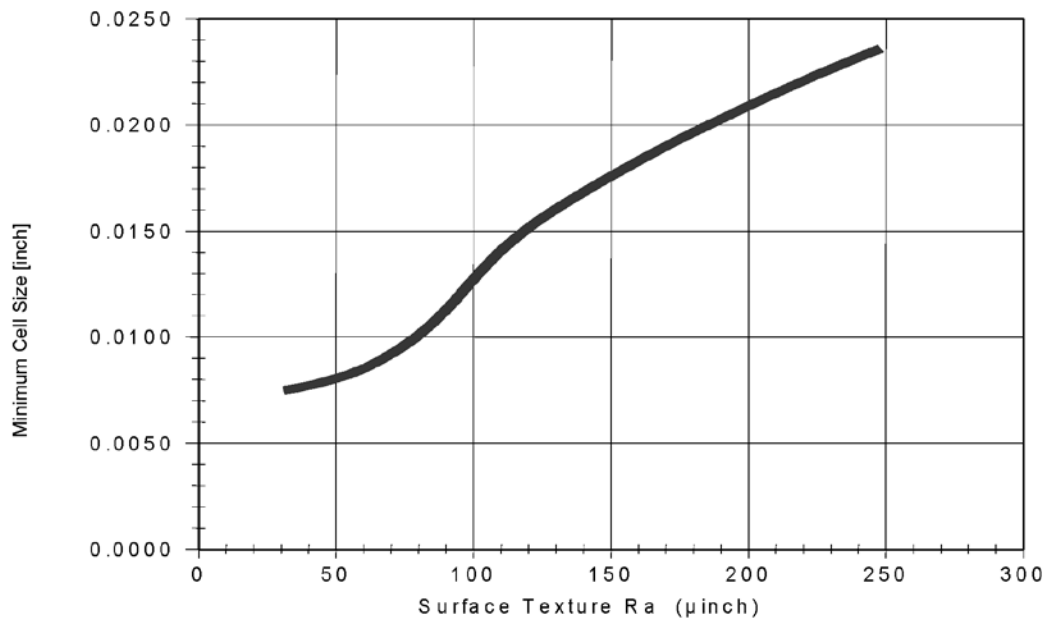
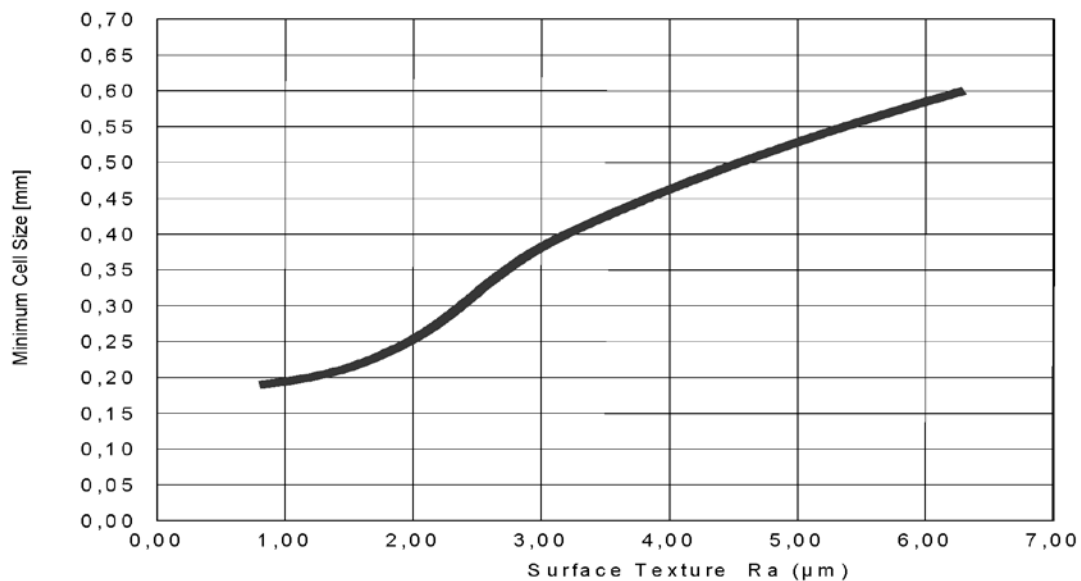
3.2.2 Requirements

a. Data Matrix Symbol Nominal Module Size:

The surface texture of the part affects the quality of a data matrix symbol produced by dot peening. Table 1 and Figures 3 and 4 show the minimum readable module size requirements for the surface texture of the part. The engineering design authority shall approve changes to the minimum module size.

Table 1 - Minimum readable module size by surface texture (Ra)

Surface Texture (Ra)		Minimum Module Size	
Microinches	Micrometers	Inches	Millimeters
32	0.8	0.0075	0.19
63	1.6	0.0087	0.22
95	2.4	0.0122	0.31
125	3.2	0.0161	0.41
250	6.3	0.0236	0.60

**Figure 3 - Minimum module size (inch) by surface texture (microinch)****Figure 4 - Minimum module size (mm) by surface texture (μm)**

b. Data Capacity:

Tables in Appendix A for dot peening show the symbol size and the data capacity compared to the nominal module size and the number of rows and columns relative to surface texture. These tables are based on practical testing.

c. Data Matrix Symbol Quality Requirements:

Below are the symbol quality requirements of the data matrix and marking equipment, but these may vary according to the design requirements and responsibility.

- Dot depth is subject to engineering design requirements. The dot depth is based upon the requirements for process, environment survivability, and other material considerations.
- Stylus radius is an engineering design requirement. The maximum tolerance shall not exceed 10% of the stylus radius.
- Surface color and color consistency may be specified as an engineering design requirement. In order to maximize readability, variation in surface color should be minimized.
- Stylus cone angle (reference α in Appendix B) is an engineering design requirement. The cone angles permitted are 60, 90, and 120 degrees. The tolerance on the cone angle shall be ± 2 degrees. For general quality of mark and stylus life, stylus cone angle of 120 degrees is preferred.
- Stylus point finish shall be polished. Surface texture shall not exceed 32 microinches or 0.8 μm . Guidance instructions for grinding are provided in Appendix B.
- Stylus point concentricity should be 0.04 mm (0.0016 inch) total indicator reading or 0.02 mm (0.0008 inch) radial point displacement. Point concentricity is referenced to stylus centerline. Hand held grinding of stylus points is not permitted.
- Dot size shall not exceed 105% of the nominal module size and not be less than 60% of the nominal module size. The ovality (see Figure 5) of the dot shall not exceed 20% of the module size. No more than 2% of the total number of modules may contain dots that are outside of these ranges. The minimum dot size shall not be less than 0.132 mm (0.0054 inch), unless approved by engineering design authority.

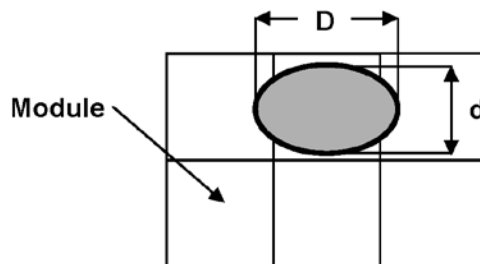


Figure 5 - Definition of ovality
($D-d \leq 20\%$ of the module size)

- Table 2 gives limits for dot size and dot center offset useable; whatever the nominal module size.

Table 2 - Limits for dot size and dot center offset

Characteristic	Requirement
Stylus Angle	120, 90, or 60 degrees
Stylus Point Radius	Subject to Engineering Design Requirements
Dot Size (% of the nominal module size)	60 to 105%
Dot Center Offset (% of the nominal module size)	0 to 20%
Angle of Distortion	±7 degrees

- Figures 6 and 7 show definition of nominal module size, dot center offset, and dot size.
- Appendix C contains examples of required tolerances in comparison to the nominal module sizes (Table C1 in inches and Table C2 in millimeters).

d. Data Matrix Symbology Marking on Colored or Coated Surfaces:

When marking is located on a colored or coated surface, the marking parameters should be validated in an actual production line environment on production or representative parts. The marking process shall demonstrate all requirements contained herein, and be verified and validated as defined in Sections 4 and 5.

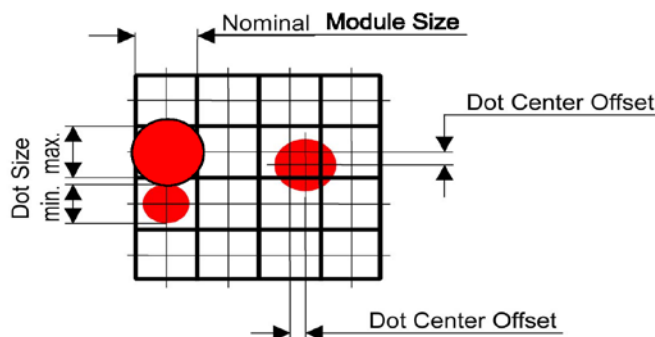


Figure 6 - Definition of nominal module size, dot size, and dot center offset

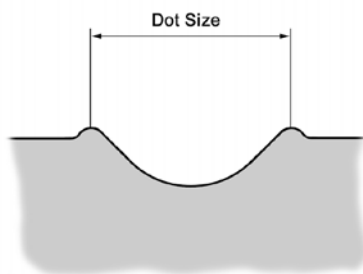


Figure 7 - Detail definition of dot size

e. Data Matrix Symbology Marking on Surfaces which are Subject to Further Surface Treatments by Abrasive Methods:

Surface treatments like shot peening and spindle deburr can affect the quality of a data matrix symbol. Therefore, the marking parameters should be validated in an actual production line environment on production parts post-surface treatment. The marking process shall demonstrate all requirements contained herein, and be verified and validated as defined in Sections 4 and 5.

3.3 Laser

3.3.1 Description of Process

a. Laser Marking:

Laser marking is a process which uses the thermal energy of the laser beam to vaporize, melt/bond, or change the condition of the surface (see Figure 8).

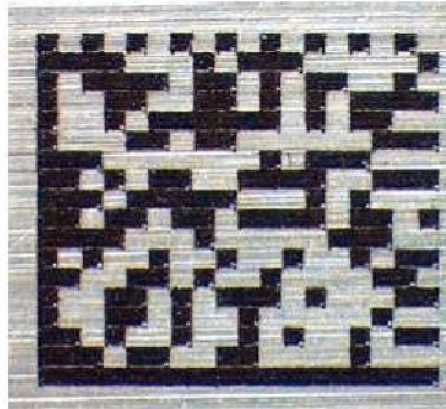


Figure 8 - Laser marking data matrix example

Due to the interaction of the laser beam with the material surface, laser marking shall not be used in the following circumstances, unless specifically approved by engineering design authority:

- Classified components. *
- Titanium alloys.

* Parts classification is the responsibility of the engineering design authority and will be determined by results of an appropriate failure analysis. Parts classification refers to the component type, the failure of which will seriously hamper operation. Parts classification will be instructed by component definition.

NOTE: Any deviation from the stated requirements requires engineering design authority.

b. General Information:

Any laser marking system consists of a laser source (e.g., Nd:YAG, CO₂) and a beam delivery system (optics). The laser beam will be generated as a cone of light, which is focused by the beam delivery system such that a parallel beam of light will be delivered at a particular distance from the final lens (working distance). The beam remains parallel for a set distance before beginning to diverge again, this distance being defined as the depth of field of the laser; again being dependent on the particular optical configuration. The diameter of the beam is known as the laser spot size. All of these parameters are dependent on the particular optical configuration of the laser marking station. See Figure 9 for a diagram illustrating a typical laser beam profile at working range.

In theory, to ensure acceptable quality of the mark, the laser shall impinge on the surface to be marked where the beam is parallel (i.e., nominally at the working distance of the final lens). Any height variation in the surface to be marked, due to part curvature or other geometrical changes, should not exceed the depth of field. Deviations from this will lead to loss of clarity of the mark as the beam goes out of focus. Additionally, it should be noted that, as the laser spot size determines the area of impingement of the beam, it is not possible to create a data matrix where the nominal module size is less than the laser spot size.