SAE Aerospace
An SAE International Group

AEROSPACE STANDARD

SAE AS9132

REV. A

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Superseding AS9132

(R) Data Matrix Quality Requirements for Parts Marking

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1. SCOPE:

This SAE Aerospace Standard (AS) defines uniform Quality and Technical requirements relative to metallic parts marking performed in using "Data Matrix symbology" used within the aerospace industry. The ISO/IEC 16022 specifies general requirements (data character encodation, error correction rules, decoding algorithm, etc.). In addition to ISO/IEC 16022 specification, part identification with such symbology is subject to the following requirements 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.

This standard does not specify information to be encoded.

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.

1.1 Convention:

The following conventions are used in this standard:

- The words “shall” and “must” indicate mandatory requirements.
- The word “should” indicates requirements with some flexibility allowed in compliance methodology. Producers choosing other approaches to satisfy a “should” must be able to show that their approach meets the intent of the requirement of this standard.
- 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 sizes followed by inches in brackets unless otherwise stated.

2. NORMATIVE REFERENCES:

- Air Transport Association (ATA), Spec2000, chapter 9 "Bar Coding"
- ISO/IEC 16022 "Information Technology - International Symbology Specification - Data Matrix"
- AS/SJAC/PrEN 9102 Requirements "First Article Inspection Requirements"

3. MARKING REQUIREMENTS:

3.1 General Requirements:

- Rows and Columns:

  Rows and columns connected with Data Matrix symbology shall conform to ECC200 in the ISO/IEC 16022

- Square versus Rectangle:

  Matrix may be square or rectangular within ECC200 requirements. Square is preferred for easier reading.

- Quiet Zone:

  The quiet zone (margin) around the matrix shall be equal to or greater than one (1) module size.

- Round Surface:

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

- Symbol Size:

  To facilitate electronic reading of symbol, the overall symbol size should be less than one 25,4 mm (1.000 inch), outside dimension, longest side. Irrespective of matrix size used, the requirements included in this standard shall be applied.

- Angular Distortion of the symbol:

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

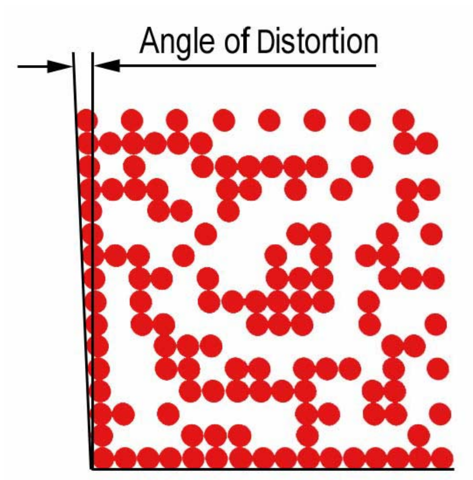


FIGURE 1 - Angle of Distortion

3.2 Dot Peening:

3.2.1 Description of Process: 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.

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.

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 must be established to help ensure consistent symbol quality. Regular maintenance schedules should be established to check for issues such as stylus wear.

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 also increase the symbol readability.

3.2.2 Instructions for Determination of Marking Parameters:

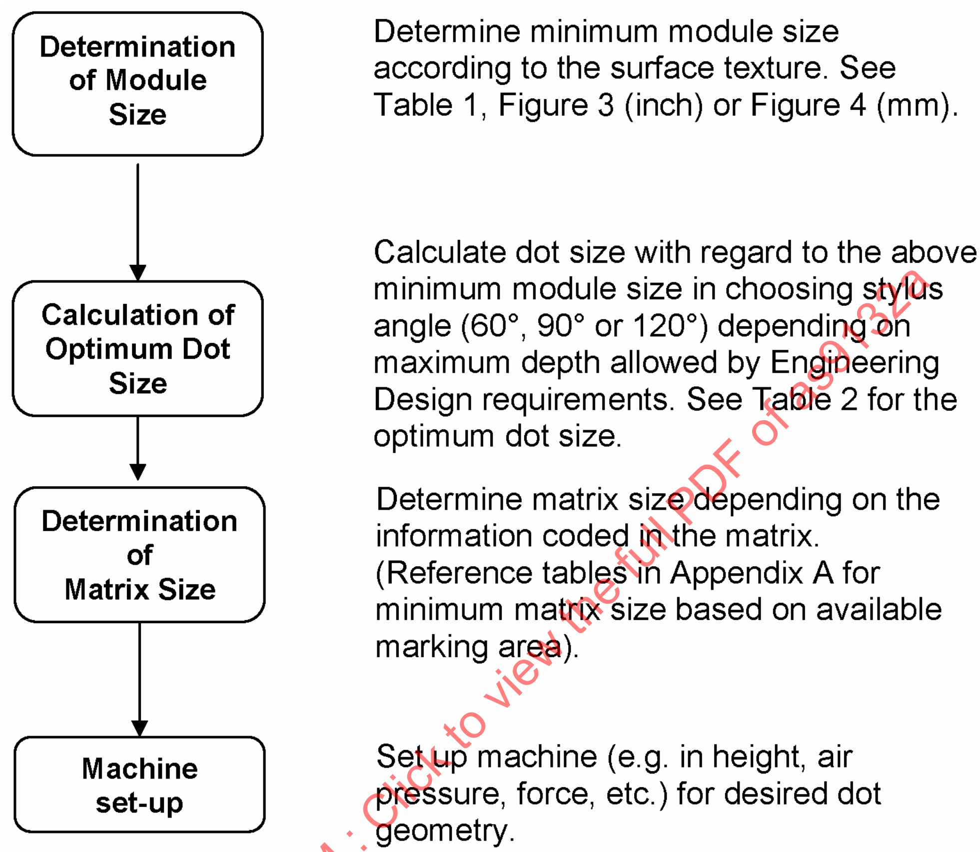


FIGURE 2

3.2.3 Requirements:

- 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 to 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

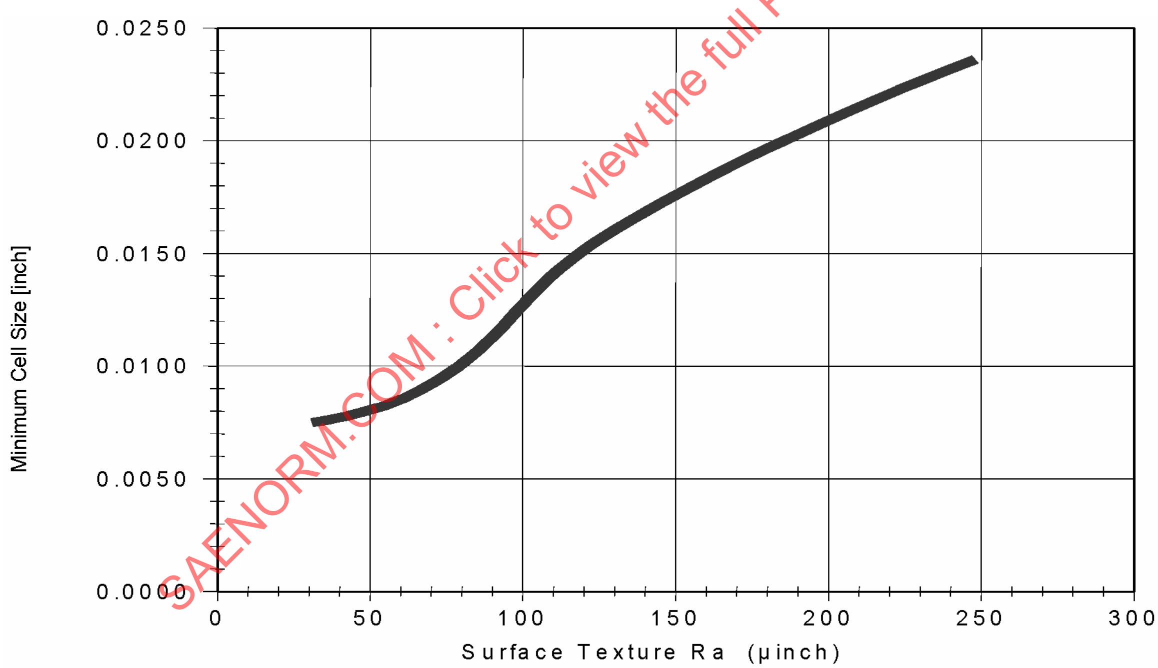


FIGURE 3 - Minimum Module Size (inch) by Surface Texture (µinch)

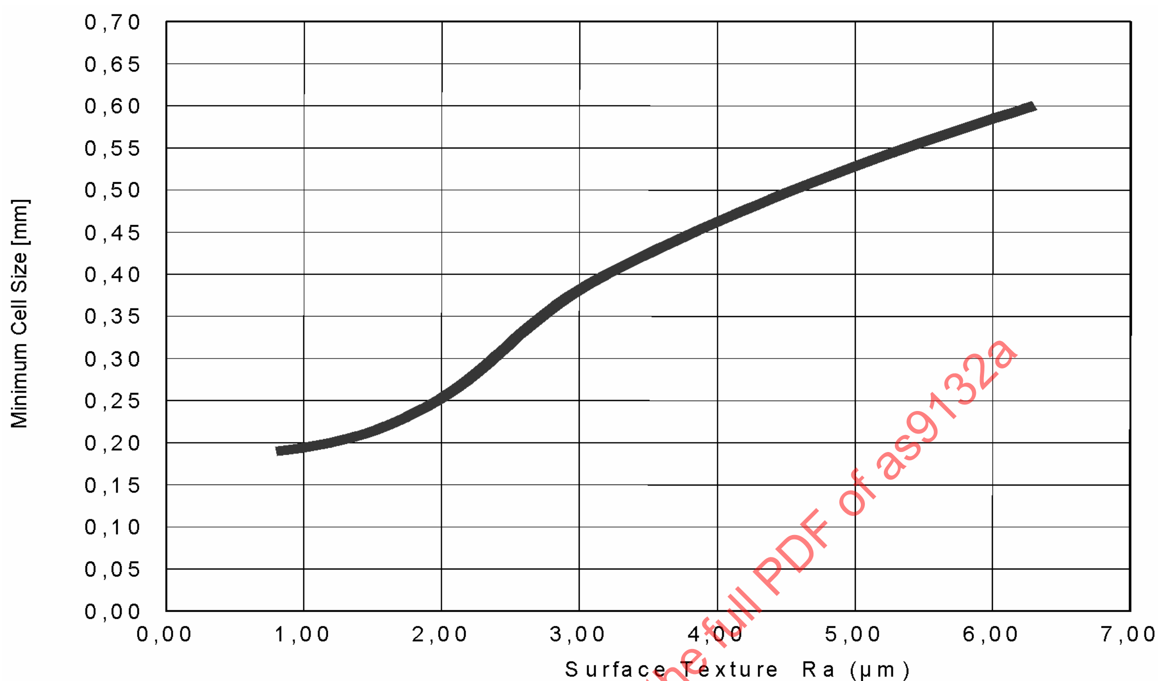


FIGURE 4 - Minimum Module Size (mm) by Surface Texture (µm)

3.2.3 (Continued):

- Data Capacity:

  For information, 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.

- 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 also an Engineering Design requirement. The Maximum tolerance shall not exceed 10% of the Stylus Radius.

3.2.3 (Continued):

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°. The tolerance on the Cone Angle shall be ±2°. For general quality of mark and stylus life, stylus cone angle of 120° is preferred.

Stylus Point Finish shall be polished. Surface texture shall not exceed 32 µinch or 0,8 µm. Guidance instructions for grinding are given 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 shall not be less than 60% of the nominal module size. The ovality (see Figure 4) 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.

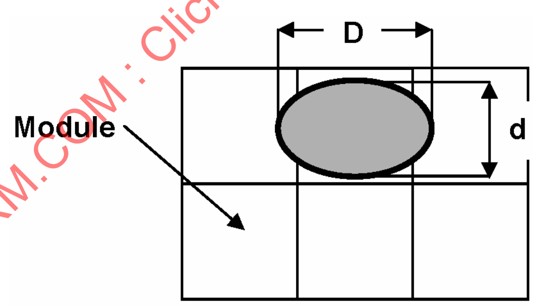


FIGURE 5 - Definition of Ovality
D-d ≤ 20% of the module size

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°, 60°
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°

3.2.3 (Continued):

Figures 6 and 7 show definition of nominal module size, dot center offset and dot size.

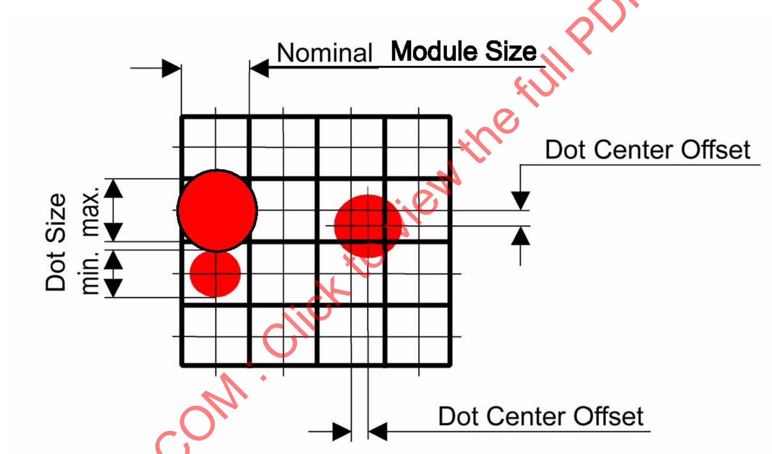


FIGURE 6 - Definition of Nominal Module Size, Dot Size and Dot Center Offset

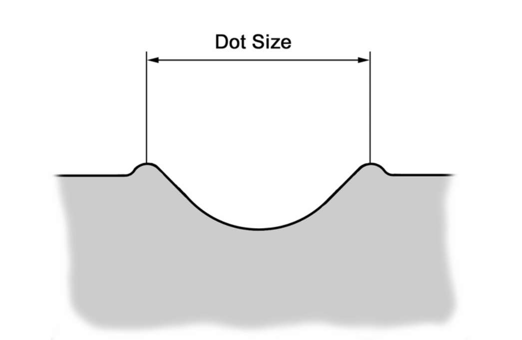


FIGURE 7 - Detail Definition of Dot Size

3.2.3 (Continued):

Appendix C (Table 1A in inches and Table 1B in millimeters) contains examples of required tolerances in comparison to the nominal module sizes.

- 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 must demonstrate all requirements contained herein, and shall be verified and validated as per Sections 4 and 5.

- 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 must demonstrate all requirements contained herein, and shall be verified and validated as per Sections 4 and 5.

3.3 Laser:

3.3.1 Description of Process:

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.

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

a. Classified* components

b. Titanium alloys

*Parts classification is the responsibility of the Engineering Design Authority and will be determined by results of an appropriate failure annalysis. 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 above list requires Engineering Design Authority.

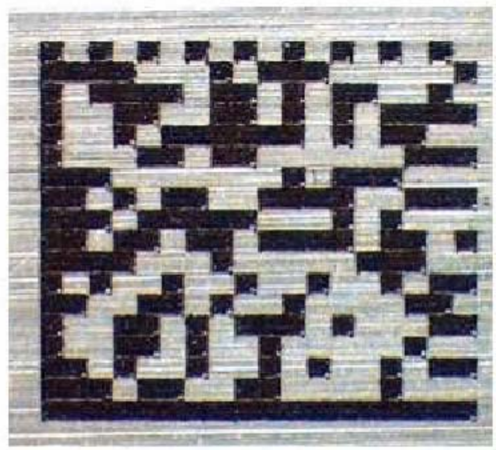


FIGURE 8

3.3.1 (Continued):

General Information

Any laser marking system consists of a laser source (Nd:YAG, CO_2, etc.) 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.

In theory, to ensure acceptable quality of the mark, the laser must 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.

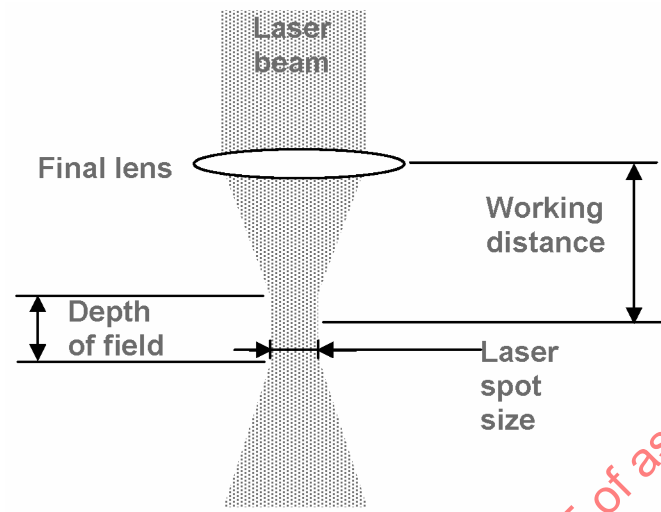


FIGURE 9 - Diagram Illustrating Typical
Laser Beam Profile at Working Range

3.3.1 (Continued):

Laser Etching/Engraving

This mark involves the use of the laser to locally vaporize and melt material, leaving an engraved mark. As the laser beam generates intense heat, there will be remnants of re-solidified material (recast layer) within the mark. In addition, a local change in the microstructural characteristics may be observed, (Heat-Affected Zone), dependent on material type. Where previous experience indicates a component experiences extreme levels of stress, caution is advised as to the suitability of this method. Additionally, the high heat input of the laser may, in certain circumstances, cause distortion of the component outside drawing limits, which may also render this marking method unsuitable. Laser etching/engraving may also be used to selectively remove a paint or other coating from a component. However consideration should be given to the possibility of localized corrosion if the coating was originally applied as a form of corrosion protection. An increase in the depth of mark will tend to improve in-service readability. However it may have a detrimental effect on local surface integrity, which is also affected by extent of recast layer, heat-affected zone and microcracking. It is therefore the responsibility of the design authority to define acceptable depth limits, dependent on component usage.

NOTE: Not all laser marking stations can produce an engraved mark on metallic materials, it depends on the lasing medium.

3.3.1 (Continued):

Laser Marking Enhancers

Materials and methods exist that can assist in laser marking by the following:

- Increase mark contrast
- Allow for marking a wider range of items
- Improve laser marking cycle time
- Reduce the amount of laser power required

1) Laser Bonding

This mark involves the use of a bonding medium, which is applied to the surface to be marked. The laser fired at this locally bonds the medium to the metal substrate, leaving a raised mark. The remains of the medium are then removed. Due to the fact that the mark is raised above the surface it should not be used on contact surfaces. In addition, the mark should not be used in areas where fretting of the mark or adjacent parts could be initiated.

NOTE: This marking process requires additional consumables. Careful control of the process is also required as the laser needs to melt the medium without melting the underlying substrate. If the latter occurs, an agglomeration of re-solidified medium and substrate is found immediately below the mark, and it is impossible to quantify the effects on material properties.

2) Laser Marking - Paint Pigmentation

Chemicals can be added in small amounts to some plastics that will react by changing color when contacted with a laser. This can be exploited by incorporating them into a paint which, when contacted by the laser, will cause a local color change through the paint without removing any of it ie no resultant loss of corrosion protection. In some instances, prolonged exposure to natural light may cause the color contrast to reduce over time and so consideration should be given to the required life of the mark."

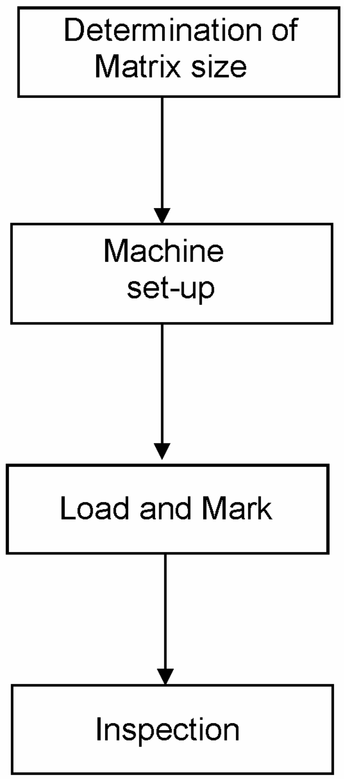
3.3.1 (Continued):

Laser Discoloration

This mark uses a lower energy density than marks involving material removal. The heat from the laser discolors the material surface without associated metal removal, resulting in a mark that is flush and smooth. Variations in color change may be achieved by varying the laser parameters, and a variety of cosmetic effects can be obtained, however normal aerospace applications will require a high contrast mark. As the mark relies on thermally induced surface discoloration, it is unsuitable for applications where the component operating temperature results in significant oxidation of the part, parts which are exposed to an aggressive environment in operation or rework, or where the risk of fretting of the mark is present. Due to its relatively non-aggressive application it can be considered suitable for thin sections and cooler components.

3.3.2 Limitations: Laser marking shall be permissible only if specified by the component definition and if it conforms to Engineering Design requirements. Where laser marking is to be used on components in single crystal materials or titanium alloys proof must be furnished that the process does not adversely affect the component's properties, with this requirement applying in addition to the test requirements as per Sections 4 and 5. Marking parts with laser must be described in a separate internal specification.

3.3.3 Instructions for Determination of Marking Parameters:



Determine matrix size (Length and width) according to the surface texture and the number of characters coded in the matrix. The matrix size is a result of the module size and the number of characters in the matrix and is calculated according to the ECC200 code automatically.

Set up machine (e.g. in height, frequency, repetition of marking, etc.) for desired Matrix geometry.

Inspect in accordance with this specification.

FIGURE 10

3.3.4 Requirements: Module depth is subject to Engineering Design requirements. The module depth is based upon the requirements for process, environment survivability and other material considerations.

Surface colors and mark contrast will affect the readability of component identification. In general, dark colors are applied to light surfaces and light markings applied to dark surfaces. The minimum contrast level between the marking and its substrate as a gray density difference should be no less than 20%. Contrast levels can be checked using a Scale of Gray Density (see Figure 11).

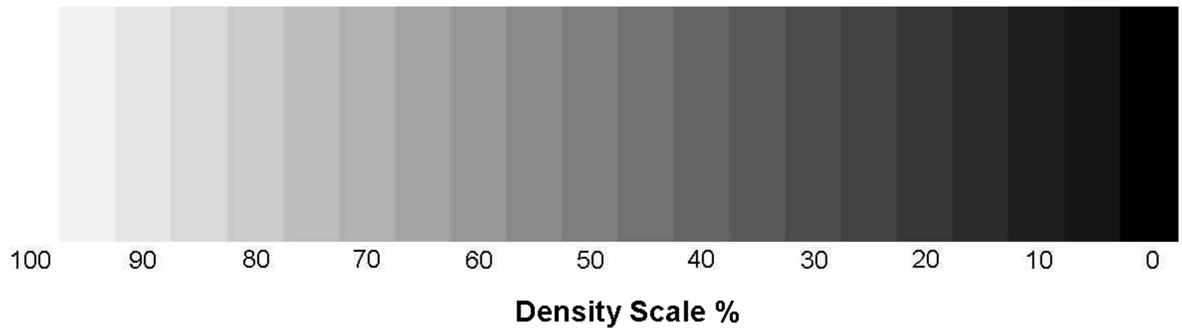


FIGURE 11 - A Scale of Gray Density

3.3.4 (Continued):

In order to maximize readability, original surface discoloration should be minimized.

The module fill shall be 60 to 105% of the nominal module size for acceptable quality. Thus an overlapping of 5% is permitted between modules.

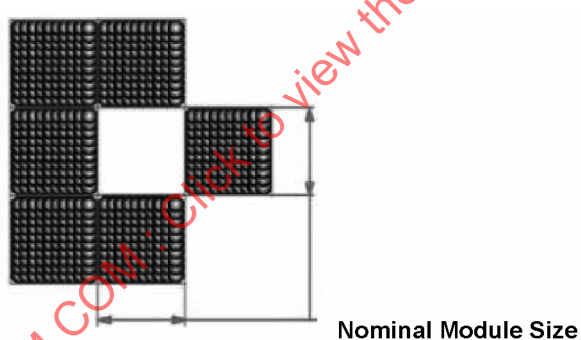


FIGURE 12 - Diagram Showing Laser Marking With Acceptable Fill of Modules

3.3.5 Metallographic: To determine marking parameters, which meet the requirements of Section 4, process trials shall be performed. In the course of these process trials representative transverse micro sections shall be evaluated to make sure that the marking depth of plain-text markings and the depth and shape of Data Matrix symbols are within the specified tolerances defined by Engineering Design authority. In addition, the acceptance limits for width of recast layer and crack depth must be adhered to. Definitions of module depth and width are illustrated below:

Module depth refers to the maximum depth achieved by the laser in an engraved mark.

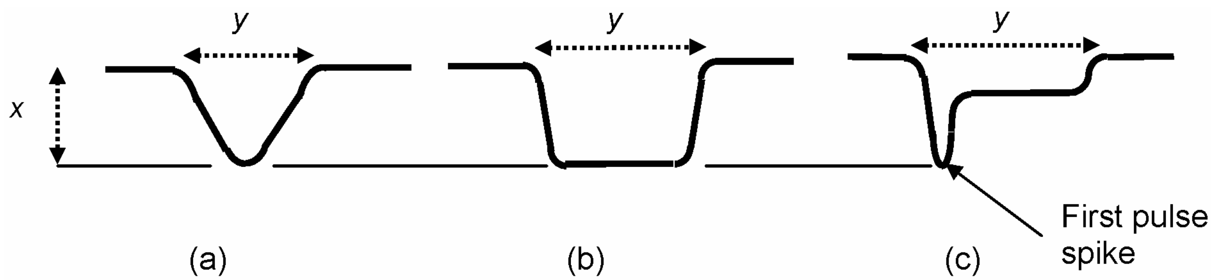


FIGURE 13 - Diagram Showing Different Laser Engraved Module Profiles, All of These Will Have the Same Module Depth (x)

3.3.5 (Continued):

NOTE: The maximum depth of engraving determines the effect on material properties. Any in-service degradation of the component, which results in material surface removal (e.g., erosion, oxidation, etc.) will obviously reduce the effective depth of the laser mark. If the module depth is not uniform across the module, loss of depth may also result in reduction of module fill. This could impact the readability of the mark in service. It is therefore desirable to make the module depth consistent across the module where possible.

Figure 13 (a) shows a typical module profile for a very small module size (typically 0,1 mm/0.004 inch) where the laser traverse spirals into the centre of the module.

Figure 13 (b) shows a typical module profile for a larger module size (typically 0,2 mm/0.008 inch) where the laser traverses along the module in a series of parallel tracks.

Figure 13 (c) shows a typical module profile using a pulsed laser to engrave a mark where first pulse suppression is not effectively employed.

Module width (y) refers to the width of material removed on an engraved mark. It also refers to the width of coloration on a discolored mark, the width of deposited material on a bonded mark.

Process trials shall generally be performed for all materials intended for laser marking. If different components from the same material are laser marked, process trials are required only on one of these components or on a representative sample. Each individual laser workstation should be validated.

3.3.5 (Continued):

In the course of the process trials the following parameters shall be specified as a minimum:

- Laser workstation (identification of laser marking facility)

- Lens focal length (in mm/inches)

- Feed rate (in mm per sec/inches per min)

- Frequency (in Hz)

- Laser power (or a proportional value)

- Marking frequency (repetition of marking/number of passes)

The results of the process trials shall be documented in a test report. If one of the above parameters is changed, the process trials must be repeated.

3.3.6 Quality Assurance: Maintenance of the laser marking facilities shall be in accordance with the group responsible for the maintenance schedule. Care shall be taken to make sure that the laser source meets the specified requirements.

To ensure a uniform laser marking quality, specimens shall be marked for at least one material at specified intervals consistent with Engineering Design authority quality requirements. Transverse micro sections shall be prepared and examined to validate that the requirements of Section 5 are met. The results shall be documented.

Prior to re-using a laser marking facility after prolonged disuse, re-location, after repairs of laser source, beam guide system or optical elements, at least 3 different materials shall be marked and inspected to make sure the requirements of Section 5 are still met.

3.4 Electro-Chemical Etching:

3.4.1 Description of Process: The process works by the electro-chemical dissolution and/or oxidation of metal from the surface being marked through a stencil impression to give the required mark.

This is achieved by sandwiching a stencil between the surface being marked (connected to the anodic polarity of the etching unit) and an electrolyte soaked pad (connected to the cathodic polarity), and passing a low voltage current between the two.

3.4.2 Scope: Electro-chemical marking shall be permissible only when specified by Engineering Design authority.

3.4.3 Sub-surface Marking: Sub-surface Electro-Chemical Etch marking is commonly achieved by the application of a combination etch. This is a direct current (DC) followed by oxide alternating current (AC). Power and time settings will vary for different material item combinations. Typically marking depths produced are 0,0025 mm/0.0001 inch minimum to 0,100 mm/0.004 inch.

3.4.4 Surface Marking: This forms a dark oxide film on the surface of the item with little or no depth. This type of mark is generally less durable than Sub-surface Electro-Chemical Etching marking. Due to this, Surface Electro-Chemical Etching shall be subject to Engineering Design Authority. The process is achieved by the application of AC current only. Power and time settings will vary for different material/item cominations.

3.4.5 Components - Condition: Components must be clean and free from corrosion or scale.

The area to be marked must be free from insulating surface treatments - paint, anodizing, etc.

3.4.6 Process Flowchart:

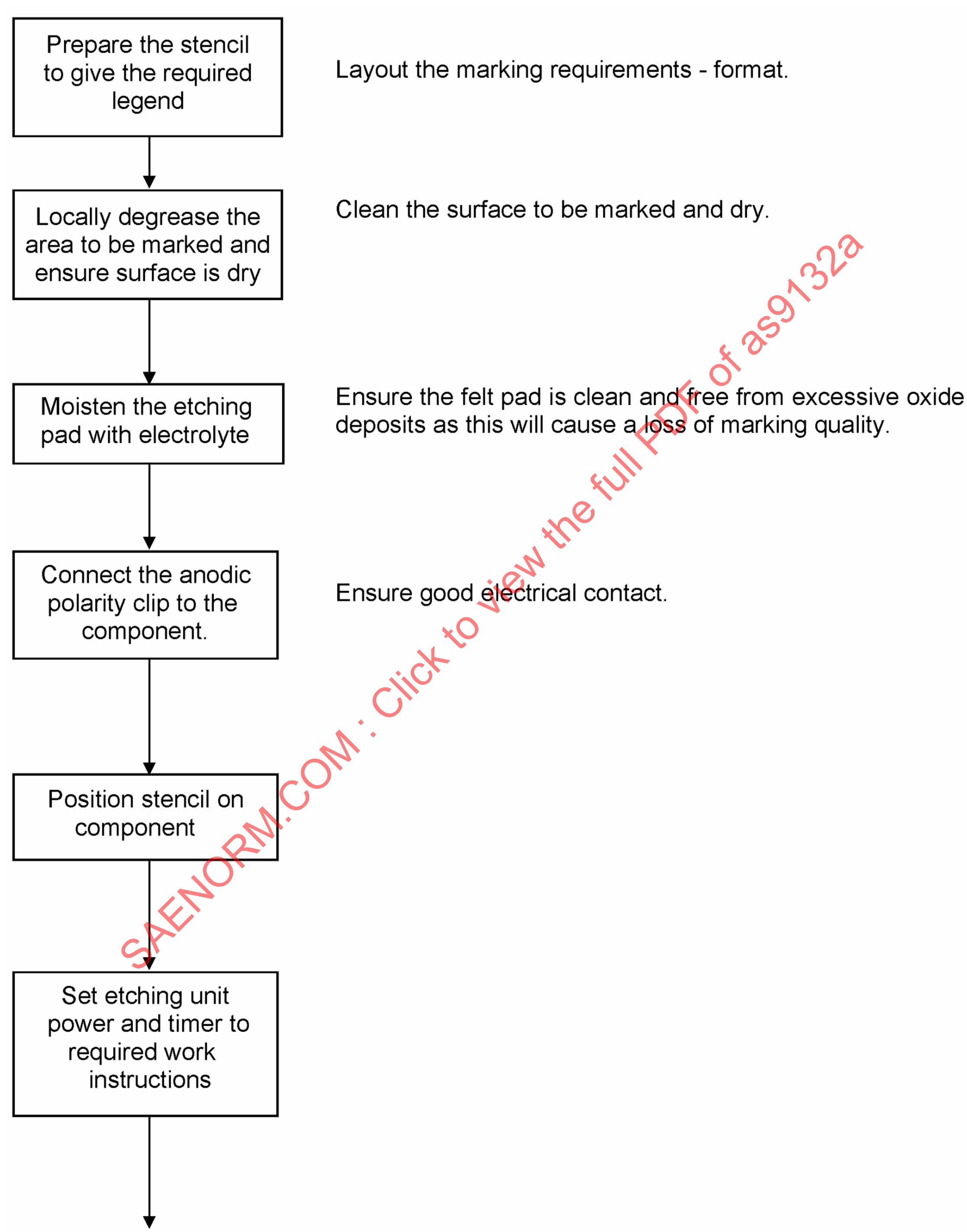


FIGURE 14

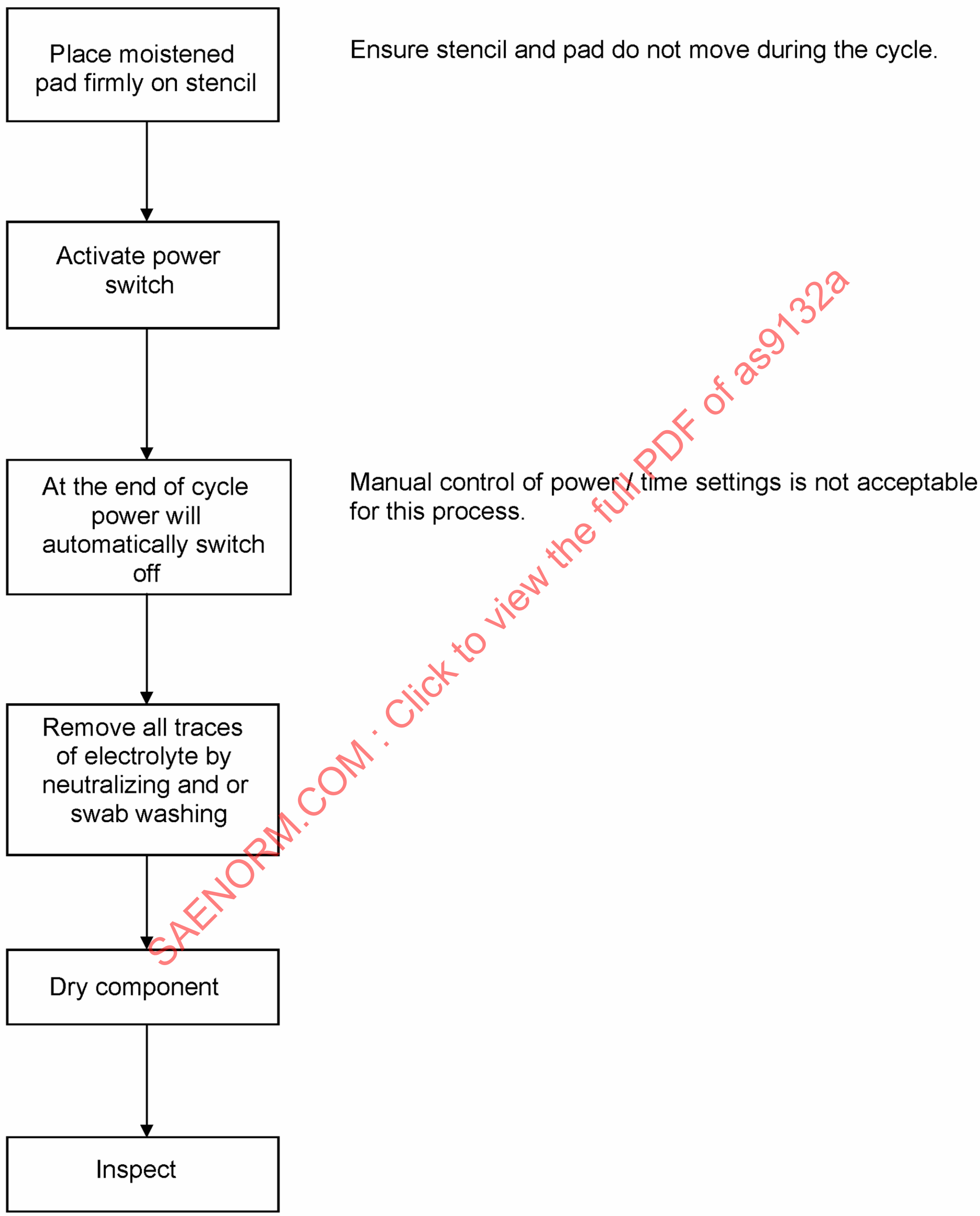


FIGURE 14 (Continued)

3.4.7 Stencil Material: Stencil material and stencil generation are critical to producing repeatable quality of coded identification. There are four common types of stencil material currently available, these are:

Photographically Etched Stencils

These are manufactured in pre-cut sizes containing impressions of the required image. The ‘marking vendor’, who will then generate the image onto a finished plate, supplies the image. The plate is then used to form the image onto the stencil, which is a high precision polyester mesh material. Once the image is photographically etched into the stencil material, the stencil will withstand marking of large volumes of parts depending on the set parameters of the marking unit. If a high current is used to provide the mark the stencil will degrade with fewer marks. This method could be used for applications where the marking data does not change between markings but, although quality produced is good, the stencils maybe relatively expensive.

Thermal Wax Stencil

This is a colored permeable paper with a wax surface. The Data Matrix image is printed onto the thin wax surface by means of a thermal process, which removes the wax to leave an image of the identification required. The method tends to be fragile; the wax degrades easily under marking processes using a high current and tends to produce a mark of poor quality in these conditions.

Die-impression

Die-impression stencil paper is widely used for producing electro-chemical etch marks in many applications. The stencil is made from a colored permeable fabric with a thin non-permeable laminate surface on one side of the stencil. A Dot Matrix printer is used to punch holes through the laminate coating in the shape of the Data Matrix image. Die-impression stencils are durable and can produce marks of a good quality. The most significant quality concerns derive from the way the stencil is produced. A 24-pin Dot Matrix printer is normally used to produce the images onto the stencil. Problems can occur with inaccuracies in the printing process, such as misalignment of the holes in the stencil paper with the pins in the printer.

Thermal transfer printed stencil - disposable

This type of stencil material is similar to the Die-impression paper, with a permeable fabric and a non-permeable laminate. The main difference being that the laminate is only microns thick. The laminate is thermally removed from the stencil using a thermal printer leaving the image on the permeable fabric. The process is generally reliable and produces a good quality mark. The stencils are normally used once and then disposed of. Slight variations in print quality are mainly due to the weave of the permeable fabric structure.

3.4.8 Electrolyte Solutions: A large number of electrolyte solutions exist, the compositions of which may vary according to component material type. However as they are all designed to produce some form of chemical attack of the material, it is vitally important that all traces of electrolyte are washed/removed/neutralized from the entire component immediately after the marking process is complete. It is also vitally important to note that when applying or removing the electrolyte, that the electrolyte and washing solution shall not be allowed to flow into any openings or cracks between parts. The type/composition and use of the electrolyte fluid shall be the responsibility of the Engineering Design authority.

3.4.9 Marking Requirements:

Inspection of Surface Color - Contrast

Surface colors and mark contrast will affect the quality of component identification. In general, dark colors are applied to light surfaces and light markings applied to dark surfaces.

The minimum contrast level between the marking and its substrate as a gray density difference should be no less than 20%.

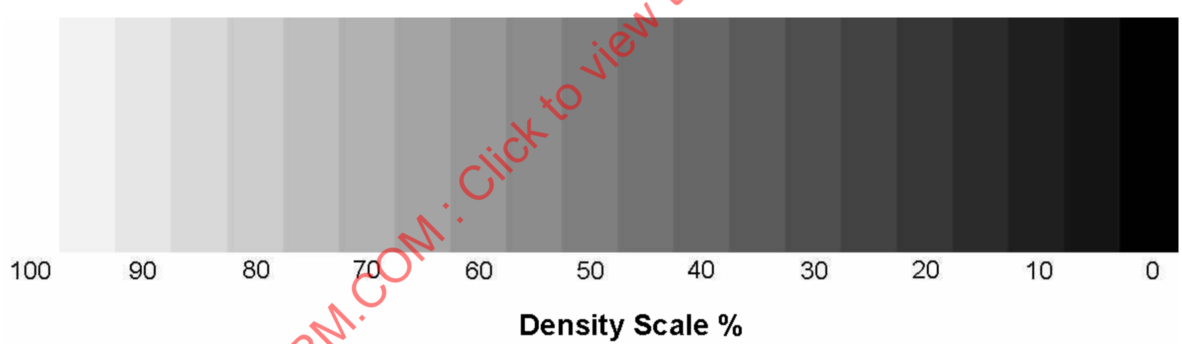


FIGURE 15 - A Scale of Gray Density

In order to maximize quality, original surface discoloration should be minimized.

Module Fill

The module size fill shall be 60 to 105% of the nominal module size. In other words, overlapping of 5% is permitted.

Visual Appearance

To maximize quality, the process output must be controlled within acceptable visual limits (see Appendix E for process guidelines).

3.4.9 (Continued):

Module Depth

Module depth is subject to Engineering Design requirements. The module depth is based upon the requirements for process, environment survivability and other material considerations.

Module Size

Nominal module size is typically in the range of 0,20 to 0,60 mm (0.008 to 0.024 inch). Changes to this range should be approved by the Engineering Design authority. Recommended nominal module size can be obtained using Table 1 section 3.2: Minimum Readable Module Size by Surface Texture in the dot peen section of this document.

3.4.10 Testing: To determine marking parameters, which meet the requirements of Section 4, process trials shall be performed.

Process trials shall be performed for all material types. If different components from the same material are electro-chemically etched, process trials are required only on one of these components or on a representative sample.

In the course of the process trials the following parameters shall be specified:

- Type of equipment

- Power Setting - AC and/or DC

- Time required for process steps

- Electrolyte

- Stencil material

Other parameters may be required and instructed by Engineering Design Authority. The results of the process trials shall be documented in a test report. If one of the above parameters is changed, the process trials must be repeated.

3.4.11 Corrosion Protection: All metal parts are susceptible to corrosion. It is therefore the responsibility of the Engineering Design authority to specify adequate corrosion protection for metallic parts at all stages of manufacturing.

3.4.12 Quality Assurance: Maintenance of the Electro-Chemical Etch marking facilities shall be in accordance with instructions from the group responsible for maintenance schedules.

4. MARKING VERIFICATION:

- All characteristics shall be verified during the First Article Inspection (FAI) per AS/SJAC/PrEN 9102 requirements. Appendix D "Example Methodology for Checking Dot Peen Characteristics" may be used as a verification guideline for Dot Peen Marking.
- FAI may also apply whenever the marking machine set up is disturbed, or after preventive maintenance or machine
- Any non-conforming marking shall be submitted to the appropriate non-conformance authority for part disposition.

5. MARKING VALIDATION AND MONITORING:

- A Quality Assurance Plan shall be developed and instituted which ensures the quality of the Data Matrix marking process and which monitors/samples the marking process for declining quality of application, which in turn affects matrix quality requirements. For example, Dot Peen monitoring may be as simple as detecting approaching dot overlap with a 10X magnifying glass.
- Marking equipment should be monitored/serviced through a Preventive Maintenance Plan recommended/developed in conjunction with the equipment supplier to ensure sufficient preventive/scheduled maintenance and to avoid marking outside of allowable limits.
- Any non-conforming marking shall be submitted to the appropriate non-conformance authority for part disposition.

6. NOTES:

6.1 The change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document.

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SAE COMMITTEE G-14, AMERICAS AEROSPACE QUALITY GROUP

APPENDIX A
DOT PEENING DATA CAPACITY GUIDELINES FOR SELECTED SURFACE TEXTURES

TABLE A1 - Surface Texture with Ra = 1,50 µm or 63 µin

Symbol Layout Row	Symbol Layout Column	Data Range	Data Capacity Num. Cap.	Data Capacity Alphanum. Cap.	Nominal Module Size 0,22 mm / Symbol Size [mm]	Nominal Module Size 0.0087 inch / Symbol Size [inch]
Square Symbol						
10	10	8x8	6	3	2,20 x 2,20	0.087 x 0.087
12	12	10x10	10	6	2,64 x 2,64	0.104 x 0.104
14	14	12x12	16	10	3,08 x 3,08	0.121 x 0.121
16	16	14x14	24	16	3,52 x 3,52	0.139 x 0.139
18	18	16x16	36	25	3,96 x 3,96	0.156 x 0.156
20	20	18x18	44	31	4,40 x 4,40	0.173 x 0.173
Rectangular Symbol						
8	18	6x16	10	6	1,76 x 3,96	0.069 x 0.156
8	32	6x14 (2x)	20	13	1,76 x 7,04	0.069 x 0.277
12	26	10x24	32	22	2,64 x 5,72	0.104 x 0.225

TABLE A2 - Surface Texture with Ra = 2,40 µm or 95 µin

Symbol Layout Row	Symbol Layout Column	Data Range	Data Capacity Num. Cap.	Data Capacity Alphanum. Cap.	Nominal Module Size 0,31 mm / Symbol Size [mm]	Nominal Module Size 0.012 inch / Symbol Size [inch]
Square Symbol						
10	10	8x8	6	3	3,10 x 3,10	0.122 x 0.122
12	12	10x10	10	6	3,72 x 3,72	0.146 x 0.146
14	14	12x12	16	10	4,34 x 4,34	0.171 x 0.171
16	16	14x14	24	16	4,96 x 4,96	0.195 x 0.195
18	18	16x16	36	25	5,58 x 5,58	0.220 x 0.220
20	20	18x18	44	31	6,20 x 6,20	0.244 x 0.244
Rectangular Symbol						
8	18	6x16	10	6	2,48 x 5,58	0.098 x 0.220
8	32	6x14 (2x)	20	13	2,48 x 9,92	0.098 x 0.391
12	26	10x24	32	22	3,72 x 8,06	0.146 x 0.317

TABLE A3 - Surface Texture with Ra = 3,25 µm or 125 µin

Symbol Layout Row	Symbol Layout Column	Data Range	Data Capacity Num. Cap.	Data Capacity Alphanum. Cap.	Nominal Module Size 0,41 mm — Symbol Size [mm]	Nominal Module Size 0.0161 inch — Symbol Size [inch]
Square Symbol						
10	10	8x8	6	3	4,10 x 4,10	0.161 x 0.161
12	12	10x10	10	6	4,92 x 4,92	0.194 x 0.194
14	14	12x12	16	10	5,74 x 5,74	0.226 x 0.226
16	16	14x14	24	16	6,56 x 6,56	0.258 x 0.258
18	18	16x16	36	25	7,38 x 7,38	0.291 x 0.291
20	20	18x18	44	31	8,20 x 8,20	0.323 x 0.323
Rectangular Symbol						
8	18	6x16	10	6	3,28 x 7,38	0.129 x 0.291
8	32	6x14 (2x)	20	13	3,28 x 13,12	0.129 x 0.517
12	26	10x24	32	22	4,92 x 10,66	0.194 x 0.420

TABLE A4 - Surface Texture with Ra = 3,80 µm or 150 µin

Symbol Layout Row	Symbol Layout Column	Data Range	Data Capacity Num. Cap.	Data Capacity Alphanum. Cap.	Nominal Module Size 0,45 mm — Symbol Size [mm]	Nominal Module Size 0.0177 inch — Symbol Size [inch]
Square Symbol						
10	10	8x8	6	3	4,50 x 4,50	0.177 x 0.177
12	12	10x10	10	6	5,40 x 5,40	0.213 x 0.213
14	14	12x12	16	10	6,30 x 6,30	0.248 x 0.248
16	16	14x14	24	16	7,20 x 7,20	0.283 x 0.283
18	18	16x16	36	25	8,10 x 8,10	0.319 x 0.319
20	20	18x18	44	31	9,00 x 9,00	0.354 x 0.354
Rectangular Symbol						
8	18	6x16	10	6	3,60 x 8,10	0.142 x 0.319
8	32	6x14 (2x)	20	13	3,60 x 14,40	0.142 x 0.567
12	26	10x24	32	22	5,40 x 11,70	0.213 x 0.461

APPENDIX B
DOT PEENING - RECOMMENDATION FOR STYLUS GRINDING

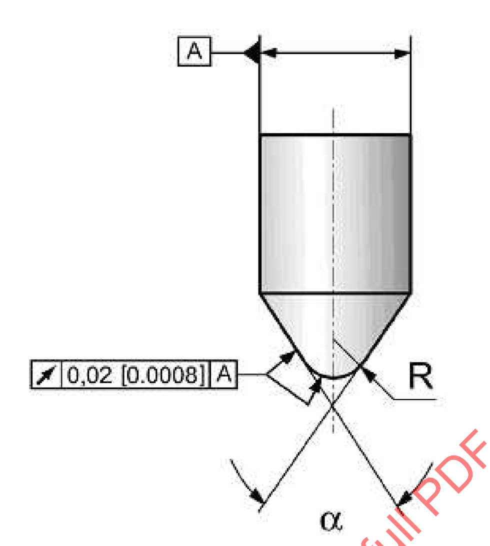

FIGURE B1 - Tolerance on Stylus

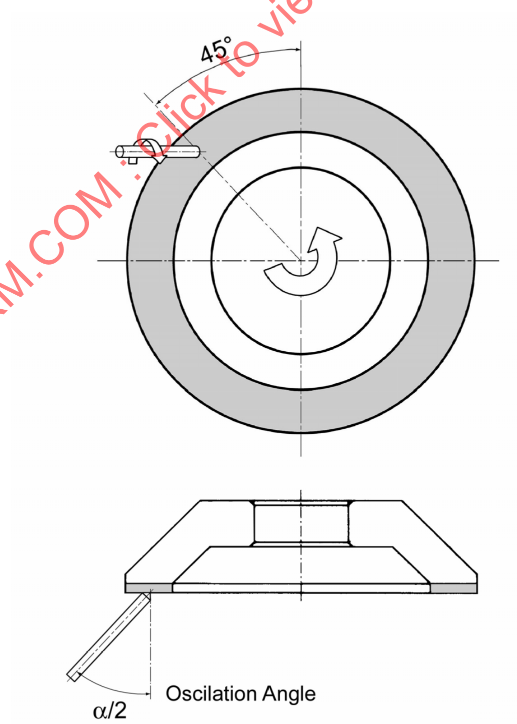

FIGURE B2 - Grinding

The grinding of the Stylus Tip is performed with 45° crossed axes of the stylus and the grinding disk. The surface may show tangential grinding scores, which reduce illumination problems.

Stylus is ground with a diamond wheel.