BS EN 9132:2017

BSI Standards Publication

Aerospace series — Quality management systems — Data Matrix Quality Requirements for Parts Marking

bsi.

National foreword

This British Standard is the UK implementation of EN 9132:2017. It supersedes BS EN 9132:2006 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ACE/1, International and European Aerospace Policy and Processes.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Aerospace series - Quality management systems - Data Matrix Quality Requirements for Parts Marking

Série aérospatiale - Systèmes de management de la qualité - Exigences qualité du marquage des pièces en code-barres Data Matrix

Luft- und Raumfahrt - Qualitätsmanagementsysteme - Data Matrix Qualitätsanforderungen für Teilemarkierung

This European Standard was approved by CEN on 4 December 2016.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (EN 9132:2017) has been prepared by the Aerospace and Defence Industries Association of Europe - Standardization (ASD-STAN).

After enquiries and votes carried out in accordance with the rules of this Association, this Standard has received the approval of the National Associations and the Official Services of the member countries of ASD, prior to its presentation to CEN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2017, and conflicting national standards shall be withdrawn at the latest by August 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 9132:2006.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Rationale

This standard has been revised to clean up the general text/content and to 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 defence industry. This standard can be invoked as a stand-alone requirement or used in conjunction with EN 9100-series standards (i. e., EN 9100, EN 9110, EN 9120).

Foreword

To assure customer satisfaction, the aviation, space, and defence 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 defence 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.

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 defence 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 millimetre (mm) sizes followed by inches (in) in parentheses, unless otherwise stated.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 9102, *Quality Systems — 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 ECC 200 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:

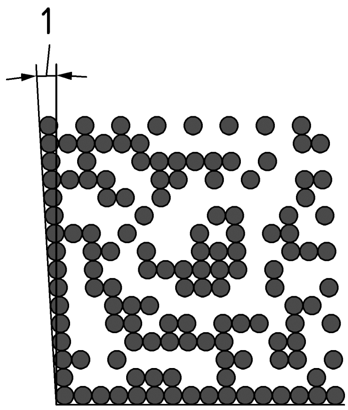
If the marking is made on a round/curved surface, the symbol coverage shall be equal to or less than 16 % of the diameter or 5 % of circumference.

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).



Key

1 Angle of Distortion

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).

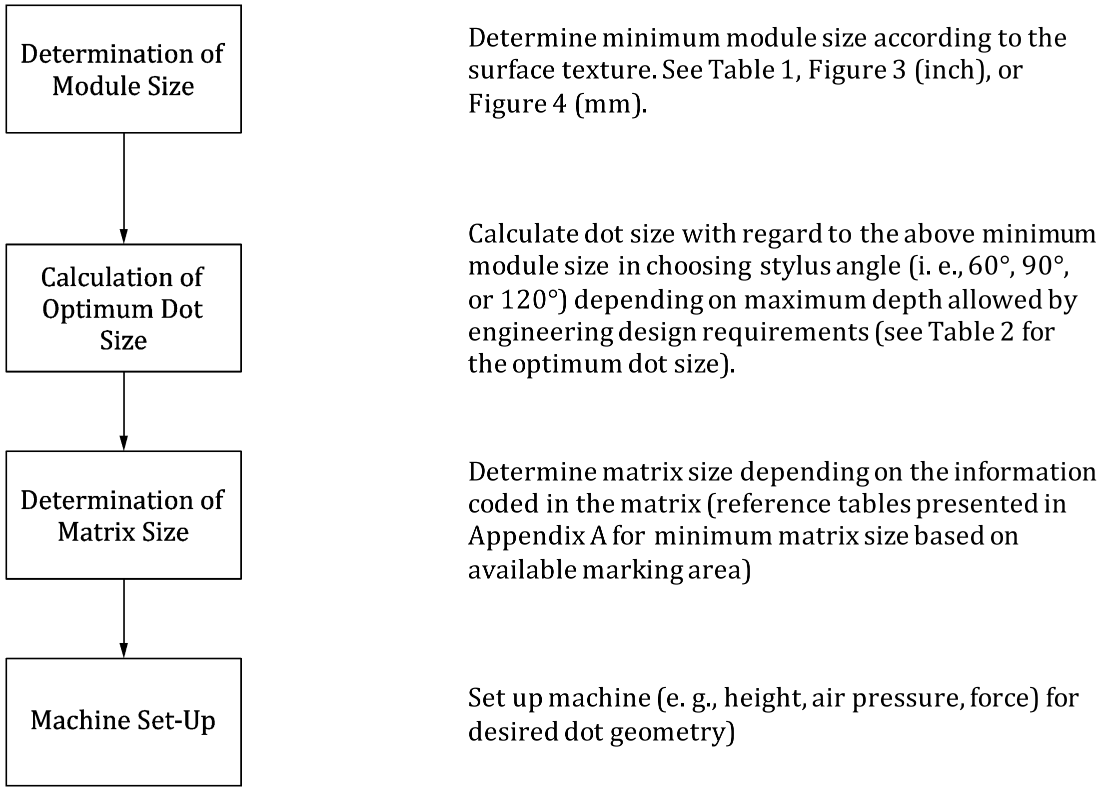


Figure 2 — Instructions for determination of marking parameters

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 discolouration, or using an air knife to blow away excess machining fluids, debris, or oil can increase the symbol readability.

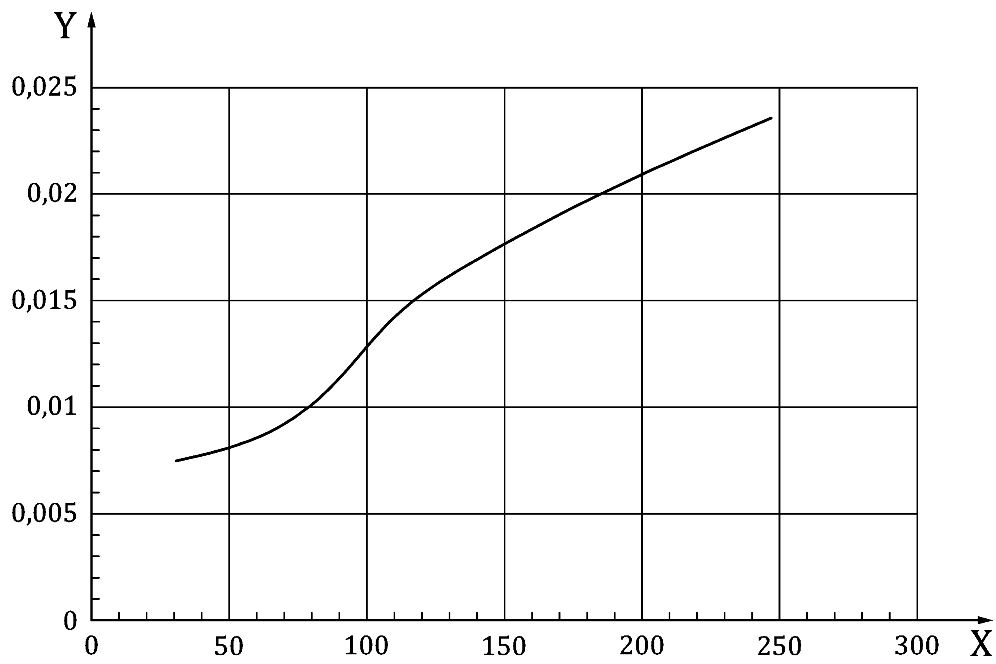
3.2.2 Requirements

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 Figure 3 and Figure 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)

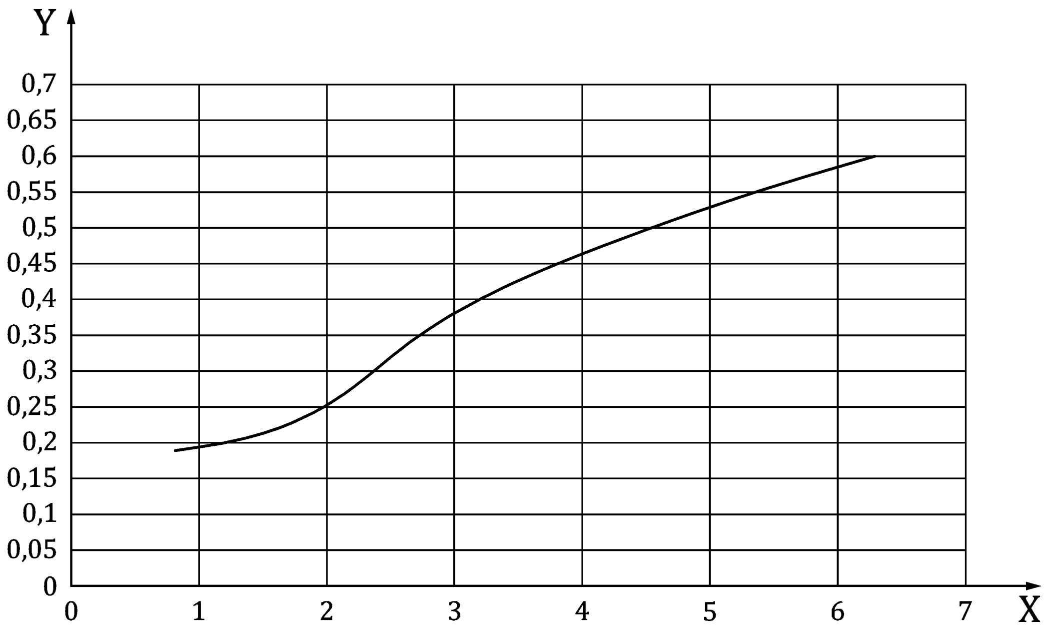
Surface Texture (Ra)		**Minimum Module Size**	
Microinches	Micrometres	Inches	Millimetres
32	0.8	0.0075	0,19
63	1.6	0.0087	0,22
95	2.4	0.0122	0,31
125	3.2	0.0161	0,41
250	6.3	0.0236	0,60



Key

Y Minimum call size [inch]
X Surface texture Ra (μ inch)

Figure 3 — Minimum module size (inch) by surface texture (μinch)



Key

Y Minimum call size [inch]
X Surface texture Ra (µ inch)

Figure 4 — Minimum module size (mm) by surface texture (µm)

b) Data capacity:

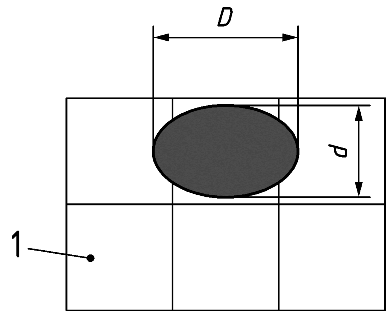
Tables in Appendix A for dot peening show the symbol size and the data capacity compared to the nominal module size and the number of rows and columns relative to surface texture. These tables are based on practical testing.

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 colour and colour consistency may be specified as an engineering design requirement. In order to maximize readability, variation in surface colour 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 µin 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 centreline. 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:



Key

1 Module

Figure 5 — Definition of ovality
(D-d ≤ 20 % of the module size)

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

Table 2 — Limits for dot size and dot centre offset

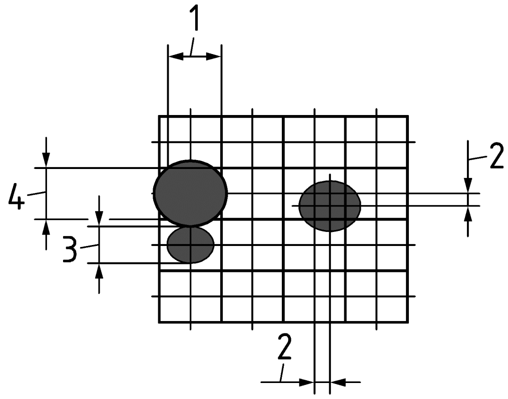
Characteristic	Requirement
Stylus Angle	120, 90 or 60 degrees
Stylus Point Radius	Subject to Engineering Design Requirements
Dot Size (% of the nominal module size)	60 to 105 %
Dot Centre Offset (% of the nominal module size)	0 to 20 %
Angle of Distortion	±7 degrees

- Figure 6 and Figure 7 show definition of nominal module size, dot centre offset, and dot size;

- Appendix C contains examples of required tolerances in comparison to the nominal module sizes (Table C.1 in inches and Table C.2 in millimetres).

d) Data matrix symbology marking on coloured or coated surfaces:

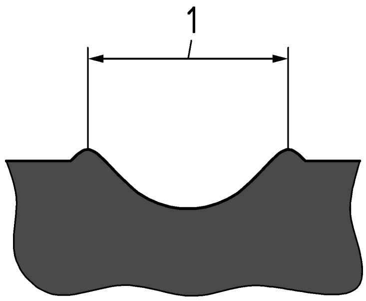
When marking is located on a coloured or coated surface, the marking parameters should be validated in an actual production line environment on production or representative parts. The marking process shall demonstrate all requirements contained herein, and be verified and validated as defined in sections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



Key

1 Nominal module size
2 Dot centre offset
3 Dot size min.
4 Dot size max.

Figure 6 — Definition of nominal module size, dot size, and dot centre offset



Key

1 Dot size

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).

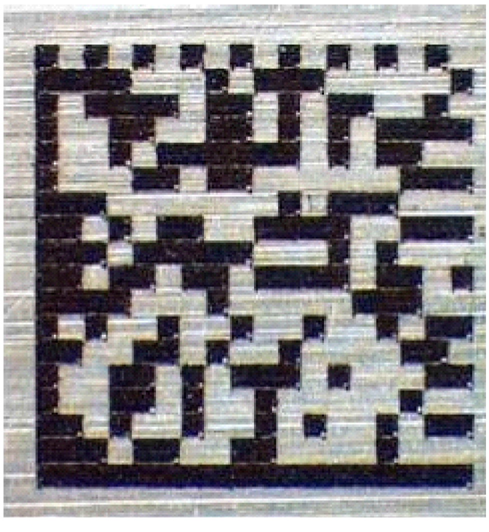


Figure 8 — Laser marking data matrix example

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:

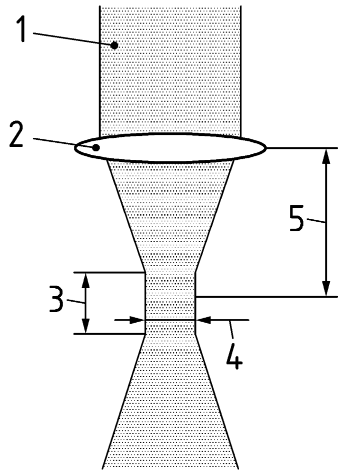
- Classified components*;
- Titanium alloys.

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, CO_2) 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.



Key

1 Laser beam
2 Final lens
3 Depth of field
4 Laser spot size
5 Working distance

Figure 9 — Diagram illustrating typical laser beam profile at working range

c) 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 (i. e., recast layer) within the mark. In addition, a local change in the micro-structural characteristics may be

* 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.

observed (i. e., 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 render this marking method unsuitable.

Laser etching/engraving may be used to selectively remove 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 affected by extent of recast layer, heat-affected zone, and micro-cracking. 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.

d) Laser marking enhancers:

Materials and methods exist that can assist in laser marking:

- increase mark contrast;
- allow for marking a wider range of items;
- improve laser marking cycle time; and
- 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 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 colour 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 colour change through the paint without removing any of it (i. e., no resultant loss of corrosion protection). In some instances, prolonged exposure to natural light may cause the colour contrast to reduce over time; so consideration should be given to the required life of the mark.

3) Laser discolouration:

This mark uses a lower energy density than marks involving material removal. The heat from the laser discolours the material surface without associated metal removal, resulting in a mark that is flush and smooth. Variations in colour change may be achieved by varying the laser parameters and a variety of cosmetic effects can be obtained; however, normal aviation, space, and defence applications will require a high contrast mark.

As the mark relies on thermally induced surface discolouration, it is unsuitable for applications where the component operating temperature results in significant oxidation of the part (e. g., 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 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 defined in sections 4 and 5. Marking parts with laser must be described in a separate internal specification. See Figure 10 for instruction on determination of marking parameters.

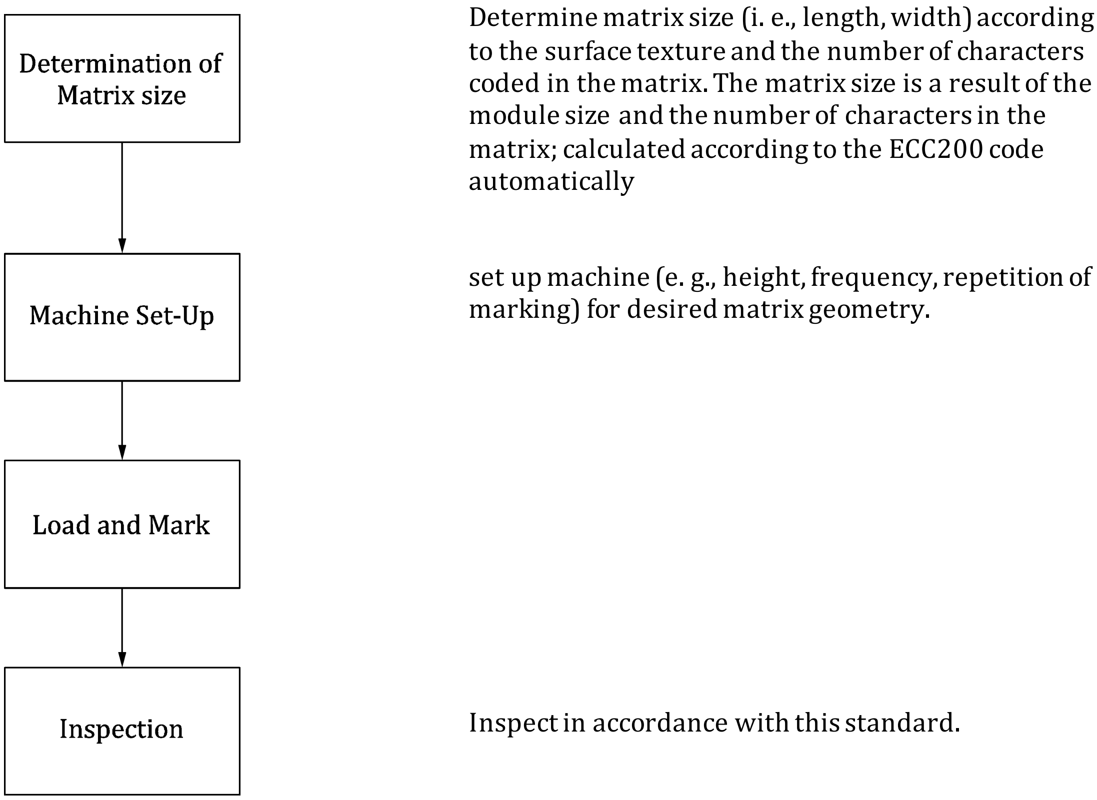
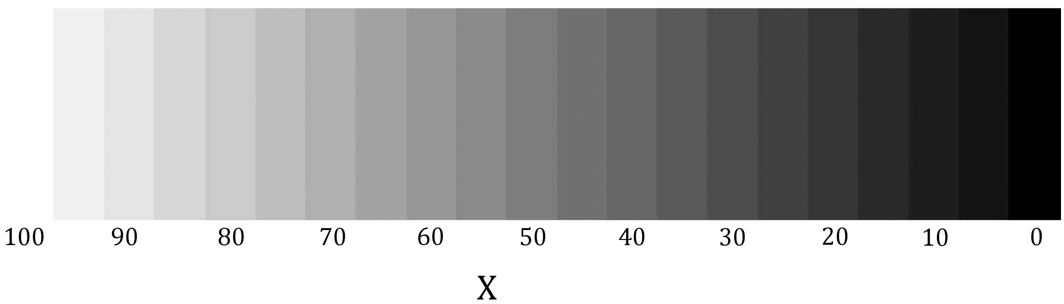


Figure 10 — Instructions for determination of marking parameters

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

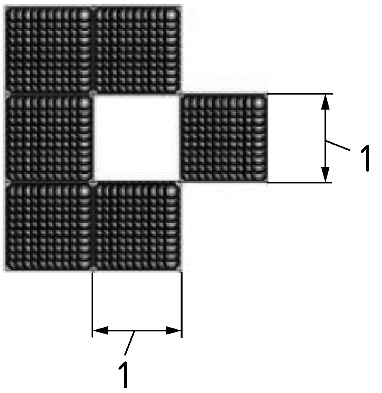


Key

X Density scale %

Figure 11 — Scale of grey density

In order to maximize readability, original surface discolouration should be minimized. The module fill shall be 60 % to 105 % of the nominal module size for acceptable quality (see Figure 12); an overlapping of 5 % is permitted between modules.



Key

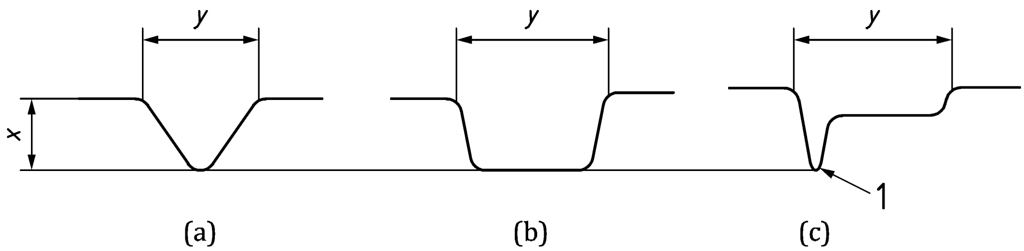
1 Nominal module size

Figure 12 — Diagram showing laser marking with acceptable fill of modules

3.3.4 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/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 shall be adhered to.

Definitions of module depth and width are illustrated below (see Figure 13); note all of these have the same module depth (x):



Key

1 First pulse spike

Figure 13 — Diagram showing different laser engraved module profiles

a) Module depth refers to the maximum depth achieved by the laser in an engraved mark;

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) will obviously reduce the effective depth of the laser mark. If the module depth is not uniform across the module, loss of depth may 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.

b) 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;

c) 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;

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

e) Figure 13 module width (y) refers to the width of material removed on an engraved mark. It also refers to the width of colouration on a discoloured mark; the width of deposited material on a bonded mark;

f) 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.

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

- Laser workstation (identification of laser marking facility);
- Lens focal length (mm/inch);
- Feed rate [mm per second (inch per minute)];
- Frequency (Hz);
- Laser power (or a proportional value); and
- 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 shall be repeated.

3.3.5 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, or repairs of laser source, beam guide system, or optical elements, at least three 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 (i. e., connected to the anodic polarity of the etching unit) and an electrolyte soaked pad (i. e., connected to the cathodic polarity), and passing a low voltage current between the two (see section 3.4.6).

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 combinations.

3.4.5 Components – Condition

Components shall be clean and free from corrosion or scale. The area to be marked shall be free from insulating surface treatments (e. g., paint, anodizing).

3.4.6 Instructions for determination of electro-chemical etch marking parameters

a) Prepare the stencil to give the required legend:

   — Layout the marking requirements - format.

b) Locally degrease the area to be marked and ensure surface is dry:

   — Clean the surface to be marked and dry.

c) Moisten the etching pad with electrolyte:

   — Ensure the felt pad is clean.

d) Connect the anodic polarity to the component:

   — Ensure good electrical contact.

e) Position stencil on component;

f) Set etching unit power and timer to required work instructions;

g) Place moistened pad firmly on stencil:

   — Ensure stencil and pad do not move during the cycle.

h) Activate power switch;

i) At the end of the cycle, power will automatically switch off:

   — Manual control of power/time setting is not acceptable for this process.

j) Remove all traces of electrolyte by neutralizing and or swab washing;

k) Dry component;

l) Inspect.

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:

a) 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 may be relatively expensive.

b) Thermal wax stencil:

This is a coloured 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.

c) Die-impression:

Die-impression stencil paper is widely used for producing electro-chemical etch marks in many applications. The stencil is made from a coloured 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 (e. g., misalignment of the holes in the stencil paper with the pins in the printer).

d) 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 vitally important to note that when applying or removing the electrolyte, 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

a) Inspection of surface colour – Contrast:

Surface colours and mark contrast will affect the quality of component identification. In general, dark colours are applied to light surfaces and light markings applied to dark surfaces. The minimum contrast level between the marking and its substrate as a grey density difference should be no less than 20 % (see Figure 11). In order to maximize quality, original surface discolouration should be minimized.

b) Module fill:

The module size fill shall be 60 % to 105 % of the nominal module size; overlapping of 5 % is permitted.

c) Visual appearance:

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

d) 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.

e) Module size:

Nominal module size is typically in the range of 0,20 mm to 0,60 mm (0.008 inch 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 (see section 3.2).

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; and
- 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 shall 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/organization responsible for maintenance schedules.

4 Marking verification

4.1 First Article Inspection (FAI) per EN 9102 standard requirements shall be followed.

4.2 Appendix E, "Example methodology for checking dot peen characteristics", may be used as a verification guideline for dot peen marking.

4.3 Any non-conforming marking shall be submitted to the appropriate non-conformance authority for part disposition.

5 Marking validation and monitoring

5.1 A Quality Assurance Plan shall be developed and instituted to ensure the quality of the data matrix marking process; it shall monitor/sample the marking process for declining quality of application. For example, dot peen monitoring may be as simple as detecting approaching dot overlap with a 10X magnifying glass.

5.2 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 avoid marking outside of allowable limits.

5.3 Any non-conforming marking shall be submitted to the appropriate non-conformance authority for part disposition.

6 Notes

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Annex A
(informative)

Dot peening data capacity guidelines for selected surface textures

Table A.1 — Surface texture with Ra = 1.50 µm or 63 microinches

Symbol Layout		Data	Data Capacity		Nominal Module Size	
Row	Column	Range	Numerical	Alpha-Numerical	0,22 mm	0.0087 inch
					Symbol Size	
					Millimetres [mm]	Inches [in]
Square Symbol						
10	10	8 x 8	6	3	2,20 x 2,20	0.087 x 0.087
12	12	10 x 10	10	6	2,64 x 2,64	0.104 x 0.104
14	14	12 x 12	16	10	3,08 x 3,08	0.121 x 0.121
16	16	14 x 14	24	16	3,52 x 3,52	0.139 x 0.139
18	18	16 x 16	36	25	3,96 x 3,96	0.156 x 0.156
20	20	18 x 18	44	31	4,40 x 4,40	0.173 x 0.173
Rectangular Symbol						
8	18	6 x 16	10	6	1,76 x 3,96	0.069 x 0.156
8	32	6 x 14 (2 x)	20	13	1,76 x 7,04	0.069 x 0.277
12	26	10 x 24	32	22	2,64 x 5,72	0.104 x 0.225

Table A.2 — Surface texture with Ra = 2.40 µm or 95 microinches

Symbol Layout		Data	Data Capacity		Nominal Module Size	
Row	Column	Range	Numerical	Alpha-Numerical	0,31 mm	0.012 inch
					Symbol Size	
					Millimetres [mm]	Inches [in]
Square Symbol						
10	10	8 x 8	6	3	3,10 x 3,10	0.122 x 0.122
12	12	10 x 10	10	6	3,72 x 3,72	0.146 x 0.146
14	14	12 x 12	16	10	4,34 x 4,34	0.171 x 0.171
16	16	14 x 14	24	16	4,96 x 4,96	0.195 x 0.195
18	18	16 x 16	36	25	5,58 x 5,58	0.220 x 0.220
20	20	18 x 18	44	31	6,20 x 6,20	0.244 x 0.244
Rectangular Symbol						
8	18	6 x 16	10	6	2,48 x 5,58	0.098 x 0.220
8	32	6 x 14 (2 x)	20	13	2,48 x 9,92	0.098 x 0.391
12	26	10 x 24	32	22	3,72 x 8,06	0.146 x 0.317

Table A.3 — Surface texture with Ra = 3.25 µm or 125 microinches

Symbol Layout		Data	Data Capacity		Nominal Module Size	
Row	Column	Range	Numerical	Alpha-Numerical	0,41 mm	0.0161 inch
					Symbol Size	
					Millimetres [mm]	Inches [in]
Square Symbol						
10	10	8 x 8	6	3	4,10 x 4,10	0.161 x 0.161
12	12	10 x 10	10	6	4,92 x 4,92	0.194 x 0.194
14	14	12 x 12	16	10	5,74 x 5,74	0.226 x 0.226
16	16	14 x 14	24	16	6,56 x 6,56	0.258 x 0.258
18	18	16 x 16	36	25	7,38 x 7,38	0.291 x 0.291
20	20	18 x 18	44	31	8,20 x 8,20	0.323 x 0.323
Rectangular Symbol						
8	18	6 x 16	10	6	3,28 x 7,38	0.129 x 0.291
8	32	6 x 14 (2 x)	20	13	3,28 x 13,12	0.129 x 0.517
12	26	10 x 24	32	22	4,92 x 10,66	0.194 x 0.420

Table A.4 — Surface texture with Ra = 3.80 µm or 150 microinches

Symbol Layout		Data	Data Capacity		Nominal Module Size	
Row	Column	Range	Numerical	Alpha-Numerical	0,45 mm	0.0177 inch
					Symbol Size	
					Millimetres [mm]	Inches [in]
Square Symbol						
10	10	8 x 8	6	3	4,50 x 4,50	0.177 x 0.177
12	12	10 x 10	10	6	5,40 x 5,40	0.213 x 0.213
14	14	12 x 12	16	10	6,30 x 6,30	0.248 x 0.248
16	16	14 x 14	24	16	7,20 x 7,20	0.283 x 0.283
18	18	16 x 16	36	25	8,10 x 8,10	0.319 x 0.319
20	20	18 x 18	44	31	9,00 x 9,00	0.354 x 0.354
Rectangular Symbol						
8	18	6 x 16	10	6	3,60 x 8,10	0.142 x 0.319
8	32	6 x 14 (2x)	20	13	3,60 x 14,40	0.142 x 0.567
12	26	10 x 24	32	22	5,40 x 11,70	0.213 x 0.461

Annex B
(informative)

Dot peening – Recommendation for stylus grinding

B.1 The grinding of the stylus tip is performed with 45° crossed axes of the stylus and the grinding disk (see Figure B.1 and Figure B.2). The surface may show tangential grinding scores, which reduce illumination problems.

NOTE Stylus is ground with a diamond wheel.

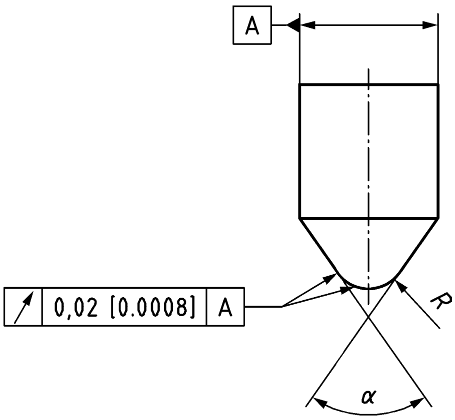
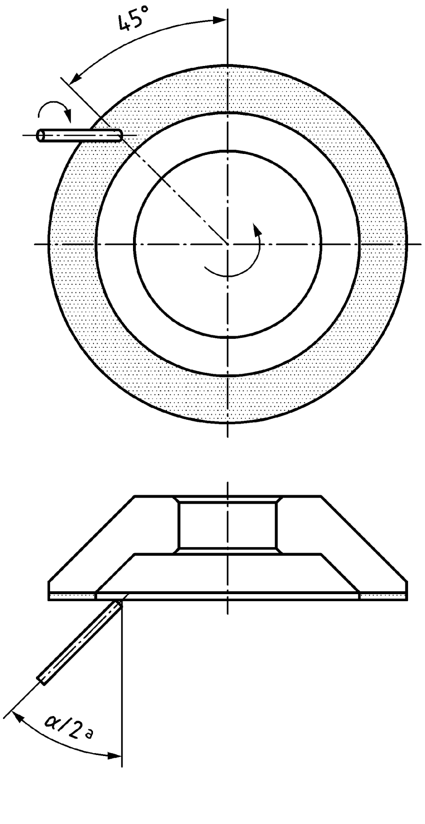


Figure B.1 — Tolerance on stylus



Key

[a] Grinding

Figure B.2 — Grinding

Annex C
(informative)

Examples of required tolerances with reference to the nominal module sizes for dot peening

Table C.1 — Requirements in inches

Nominal Module Size = 0.0087 (inch)	
Characteristic	**Requirement**
Stylus Angle	90 or 60 degrees
Stylus Point Radius	0.0039
Dot Size (diameter)	0.0052 to 0.0091
Dot Centre Offset	0.0009 to 0.0017
Angle of Distortion	±7 degrees

Nominal Module Size = 0.0122 (inch)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0.0059
Dot Size (diameter)	0.0073 to 0.0128
Dot Centre Offset	0.0012 to 0.0024
Angle of Distortion	±7 degrees

Nominal Module Size = 0.0161 (inch)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0.0098
Dot Size (diameter)	0.0097 to 0.0169
Dot Centre Offset	0.0016 to 0.0032
Angle of Distortion	±7 degrees

Nominal Module Size = 0.0177 (inch)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0.0079
Dot Size (diameter)	0.0106 to 0.0186
Dot Centre Offset	0.0018 to 0.0035
Angle of Distortion	±7 degrees

Table C.2 — Requirements in millimetres

Nominal Module Size = 0,22 (mm)	
Characteristic	**Requirement**
Stylus Angle	90 or 60 degrees
Stylus Point Radius	0,10
Dot Size (diameter)	0,132 to 0,231
Dot Centre Offset	0,022 to 0,044
Angle of Distortion	±7 degrees

Nominal Module Size = 0,31 (mm)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0,15
Dot Size (diameter)	0,186 to 0,325
Dot Centre Offset	0,031 to 0,062
Angle of Distortion	±7 degrees

Nominal Module Size = 0,41 (mm)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0,25
Dot Size (diameter)	0,246 to 0,431
Dot Centre Offset	0,041 to 0,082
Angle of Distortion	±7 degrees

Nominal Module Size = 0,45 (mm)	
Characteristic	**Requirement**
Stylus Angle	120 or 90 degrees
Stylus Point Radius	0,20
Dot Size (diameter)	0,270 to 0,473
Dot Centre Offset	0,045 to 0,090
Angle of Distortion	±7 degrees

Annex D
(informative)

Visual quality guidelines – Electro-chemical etching

D.1 Quality Assessment

D.1.1 Figure D.1 should be used as a guide to provide visual assessment of the mark and to optimize process parameters.

D.1.2 It is recommended that quality assessments of five (5) and below will require further process parameter adjustment before an acceptable output level is achieved (see section 3.4.10).

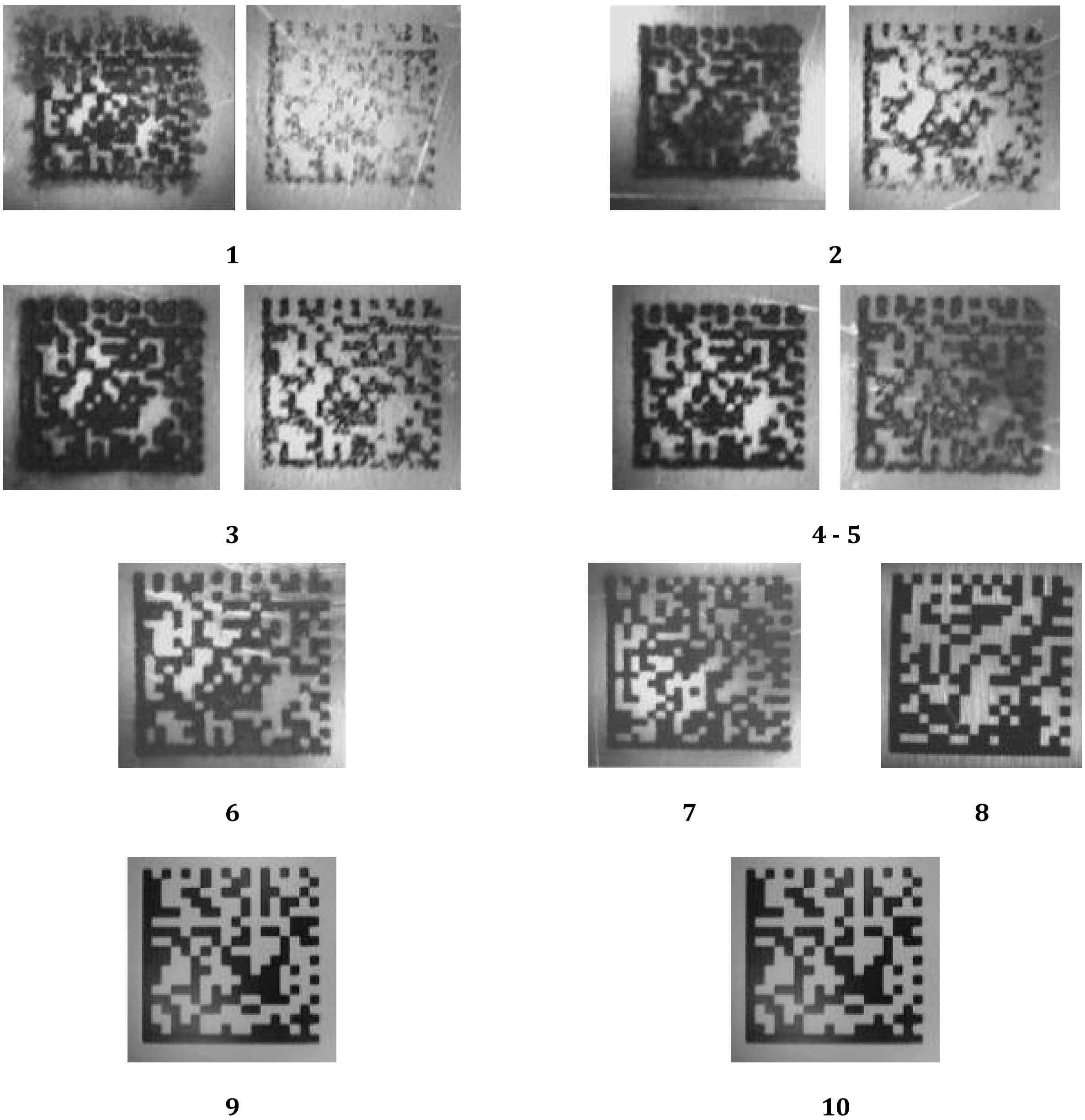
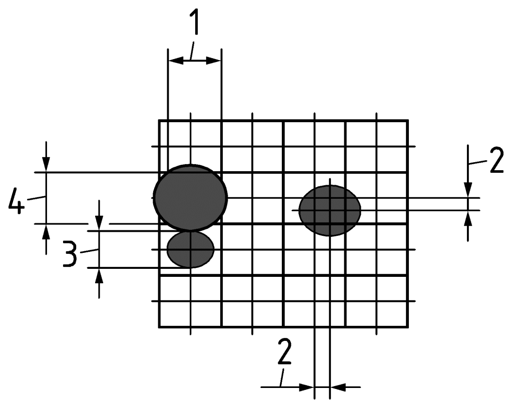


Figure D.1 — Visual quality assessment

Annex E
(informative)

Example methodology for checking dot peen characteristics

E.1 Example method for checking dot size and dot centre offset (see Figure E.1).



Key

1 Nominal module size
2 Dot centre offset
3 Dot size min.
4 Dot size max.

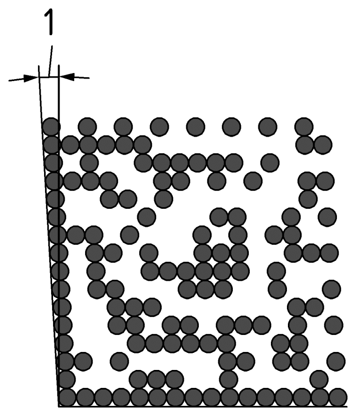
Figure E.1 — Dot size and dot centre offset

E.1.1 The verification of a data matrix symbol may be achieved by one of the following methods:

a) Magnification using appropriate optical systems;

b) Verification through camera systems and software that is capable of evaluating quality to meet the requirements herein.

E.2 Example method for checking angle of distortion (see Figure E.2).



Key

1 Angle of distortion

Figure E.2 — Angle of distortion

E.2.1 Angle of distortion may be verified by the following methods:

a) Magnification using appropriate optical systems;

b) Verification through camera systems and software that is capable of evaluating quality to meet the requirements herein.

E.3 Example method for checking dot peen depth (see Figure E.3).

E.3.1 The dot depth is a function of the stylus radius, the stylus cone angle, and the actual dot size.

E.3.2 Table E.1 contains the dot depth established from calculation, see Figure E.3 and Figure E.4. The actual dot depth may be closely approximated by measuring the tip wear of the stylus (see Figure E.5); however, actual hardness of parts and stylus, which affect the tip wear of the stylus have to be taken into account.

E.3.3 Other techniques may be used to measure actual dot depth.

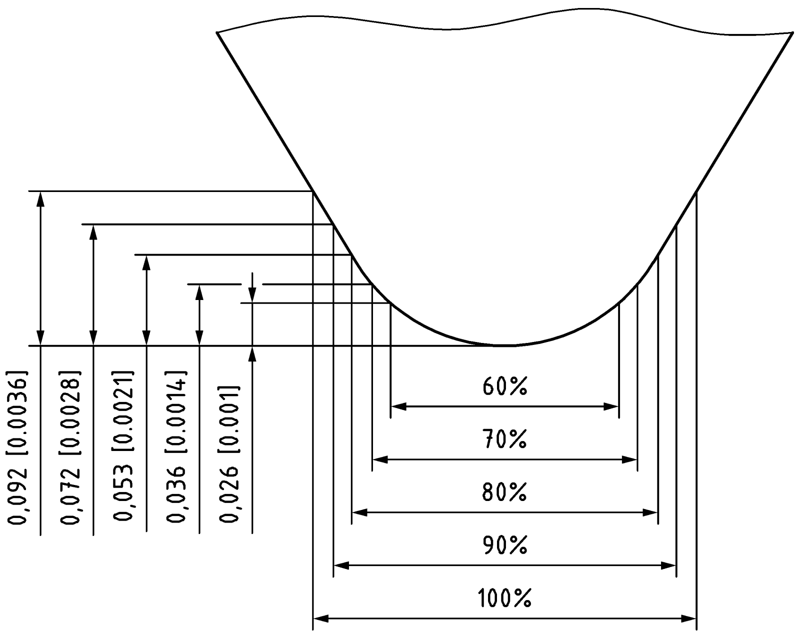
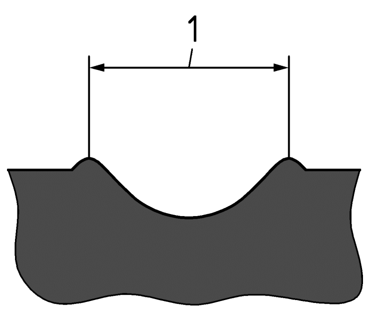


Figure E.3 — Example with 60 degree stylus angle and .004 radius

E.3.4 The dot size can be measured with appropriate magnification or use of photographic techniques involving scaled measurements (see Figure E.4).



Key

1 Dot size

Figure E.4 — Dot size measurement

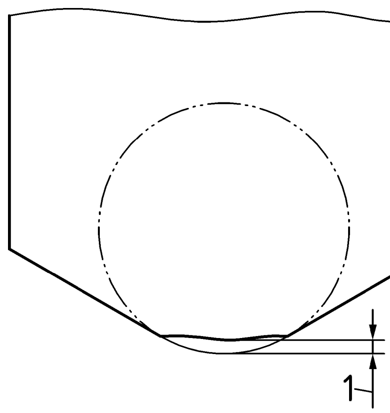
Table E.1 — Calculated dot depth *(1 of 2)*

Nominal Module Size		Dot Size			Stylus Cone Angle	Stylus Radius		Dot Depth	
[inch]	[mm]		[inch]	[mm]	[Degrees]	[inch]	[mm]	[inch]	[mm]
0.0087	0,22	105 %	0.0091	0,23	60	0.0039	0,10	0.0040	0,102
		100 %	0.0087	0,22				0.0036	0,092
		90 %	0.0078	0,20				0.0029	0,072
		80 %	0.0069	0,18				0.0021	0,053
		70 %	0.0061	0,15				0.0014	0,036
		60 %	0.0052	0,13				0.0010	0,026
		105 %	0.0091	0,23	90	0.0039	0,10	0.0030	0,075
		100 %	0.0087	0,22				0.0028	0,070
		90 %	0.0078	0,20				0.0023	0,059
		80 %	0.0069	0,18				0.0019	0,048
		70 %	0.0061	0,15				0.0014	0,036
		60 %	0.0052	0,13				0.0010	0,026
0.0122	0,31	105 %	0.0128	0,33	90	0.0059	0,15	0.0034	0,087
		100 %	0.0122	0,31				0.0033	0,084
		90 %	0.0110	0,28				0.0031	0,078
		80 %	0.0098	0,25				0.0025	0,063
		70 %	0.0085	0,22				0.0019	0,048
		60 %	0.0073	0,19				0.0013	0,033
		105 %	0.0128	0,33	120	0.0059	0,15	0.0028	0,071
		100 %	0.0122	0,31				0.0026	0,067
		90 %	0.0110	0,28				0.0023	0,058
		80 %	0.0098	0,25				0.0020	0,050
		70 %	0.0085	0,22				0.0016	0,040
		60 %	0.0073	0,19				0.0012	0,031
0.0161	0,41	105 %	0.0169	0,43	90	0.0098	0,25	0.0045	0,114
		100 %	0.0161	0,41				0.0041	0,104
		90 %	0.0145	0,37				0.0033	0,083
		80 %	0.0129	0,33				0.0025	0,063
		70 %	0.0113	0,29				0.0018	0,047
		60 %	0.0097	0,25				0.0013	0,032
		105 %	0.0169	0,43	120	0.0098	0,25	0.0034	0,086
		100 %	0.0161	0,41				0.0032	0,080
		90 %	0.0145	0,37				0.0027	0,068
		80 %	0.0129	0,33				0.0022	0,057
		70 %	0.0113	0,29				0.0018	0,045
		60 %	0.0097	0,25				0.0013	0,032

Table E.1 — Calculated dot depth *(2 of 2)*

Nominal Module Size		Dot Size			Stylus Cone Angle	Stylus Radius		Dot Depth	
[inch]	[mm]		[inch]	[mm]	[Degrees]	[inch]	[mm]	[inch]	[mm]
0.0177	0,45	105 %	0.0186	0,47	90	0.0079	0,20	0.0061	0,155
		100 %	0.0177	0,45				0.0057	0,144
		90 %	0.0159	0,41				0.0048	0,121
		80 %	0.0142	0,36				0.0040	0,102
		70 %	0.0124	0,32				0.0030	0,077
		60 %	0.0106	0,27				0.0021	0,053
		105 %	0.0186	0,47	120	0.0079	0,20	0.0041	0,106
		100 %	0.0177	0,45				0.0039	0,100
		90 %	0.0159	0,41				0.0034	0,087
		80 %	0.0142	0,36				0.0029	0,074
		70 %	0.0124	0,32				0.0024	0,060
		60 %	0.0106	0,27				0.0019	0,048

E.3.5 The wear of a stylus is best measured with a comparator. Subcontracting the stylus wear measurement (see Figure E.5) from the calculated dot depth (see Table E.1) yields a sufficiently accurate approximation of the achieved dot depth.



Key

1 Stylus wear

Figure E.5 — Stylus wear measurement

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