Rolls-Royce

Direct Part Marking

Implementation Guide

Information contained within this document may become out of date with revisions to the other documents. Information is provided as a guide only.

The responsibility for complying with Rolls-Royce requirements rests solely with Rolls-Royce's suppliers and partners, and any advice or guidance offered by Rolls-Royce does not imply any liability on behalf of Rolls-Royce to its suppliers or partners whatsoever as a consequence of utilising or otherwise any such advice or guidance offered.

Issue 1 June 2004 - Vcom 9897

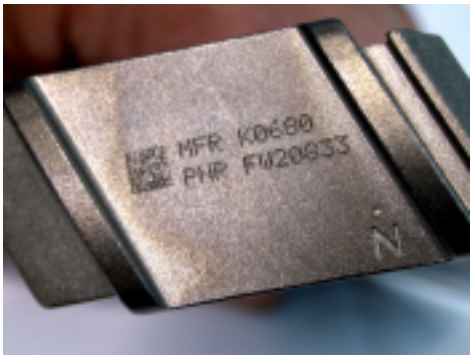
Introduction

Direct Part Marking – sometimes referred to as Machine-readable identification is fast becoming a commercial practice throughout many industry sectors worldwide. The process is used to identify a large variety of end items.
Rolls-Royce and other aero engine and air frame manufacturers around the world are committed to full implementation of data matrix identification in line with customer and industry standards.
Customer demand for machine-readable identification is headed by the United States Department of Defence (DoD) following the Unique Identification policy issued in July 2003 that requires machine-readable unique identification across many commodities for solicitations issued on or after January 1st 2004. The DoD policy merely underpins the work that both Airbus and Boeing started many years earlier to introduce machine-readable identification across many aerospace parts.

The accuracy and speed of data exchanged within aviation can be significantly improved by the use of intelligent electronic coding that removes or significantly reduces the need for manual keying.
Bar coding (this term applies to both 1Dimensional (1D) and 2 Dimensional (2D) types) provides an accurate and easy method for both data usage and storage for information technology management systems.

The 1D bar code has been used in many industries now for over 20 years but is mainly used for label or package type applications where space and contrast issues are not normally a major consideration. Today the challenge to extend the opportunity for bar coding business improvements has seen the introduction of 2D data matrix codes applied directly to aerospace components.
The 2D data matrix codes are used in Direct Part Marking applications due mainly to their ability to store data more effectively in 2 directions and thus require much less space on the component surface. They can also perform with extremely low levels of contrast as in the case of dot peen applications.

Machine-readable (data matrix) code



Marking Methods to Apply Direct Part Marking

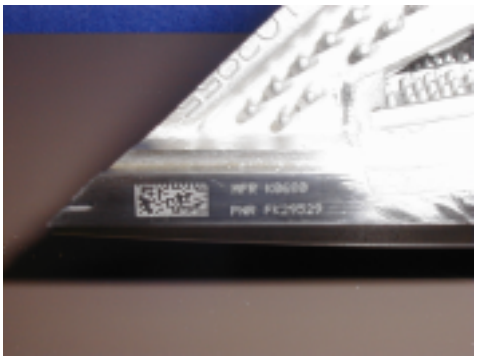
The primary manufacturing methods used to apply Direct Part Marking are:

- Dot Peen
- Electro Chemical Etching
- Laser Marking
- Ink Jet

Typical factors that influence the actual marking process decision are material composition, environmental operation, production volume and space permitted for marking. These factors and more are all considered by the Engineering Design authority and are applied to the component definition or specification.
It is important to stress that the component definition is the only authority to instruct the permitted marking procces(es) for any given item. Changes to the component definition must be submitted by drawing alteration request for design consideration.

Dot Peen

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 / cell size, 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 project is to control the variables affecting the consistency of the process. Symbol verification systems can also 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 quality.

To achieve acceptable quality and process consistency Rolls-Royce recommends careful consideration when selecting dot peen systems and the following features should be reviewed before final selection or equipment upgrade.

Power System

Consistent force delivered at the point of contact between stylus and component is important to maintain acceptable dot size and code quality. It is recommended that electromechanically driven pin movement is selected for overall consistency. Where pneumatic control is employed manufacturers are recommended that control of air pressure must be keep within limits of +/- 2.5 PSI.

Stylus to Target Surface - Height Control

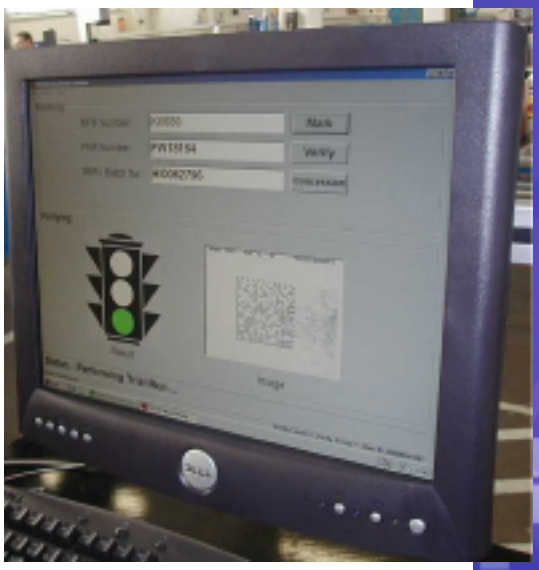
Dot size is controlled primarily by the amount of force delivered to the stylus and the distance the stylus needs to travel before impact. It is therefore important to consider how to control this distance to maintain an acceptable process capability. The main factor to consider is the part location in a holding device or fixture. This holding device must provide accuracy and repeatability to ensure that the component is offered to the marking machine in the same position every time in every axis. The actual distance of the stylus to surface height is achieved during set up procedure or postproduction trials. This height can be judged manually by the use of calibrated gauges such as slips or by the employment of a device such as an automatic sensing control – auto sense. This auto sense searches out the surface and immediately after contact the stylus retracts to a set distance before commencing with the marking process. Where auto sense is selected it is recommended that manufacturers obtain certificates of performance from technology suppliers to ensure any system selected is repeatable and accurate.

Axis Movement - Accuracy

The build quality and overall accuracy of movement for any dot peen solution is vital for acceptable component quality, repeatability and life of operation. Many traditional low-end specification dot peen machines producing human readable identification only may not be suitable for data matrix applications or subsequent upgrading. The accuracy in axis movement required for data matrix operation is typical around 0,02mm.

Verification

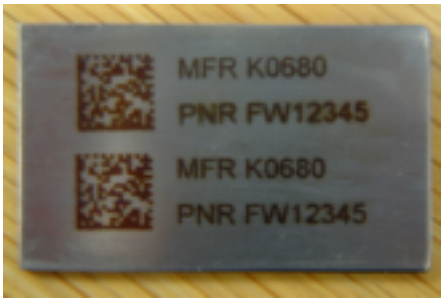
Many technology suppliers are now offering vision verification as an option for monitoring and inspecting code quality after the marking operation. This option would normally account for a significant proportion of the total solution cost so selection of vision verification requires careful consideration. The addition of vision verification will require camera, lighting, PC and verification software for operation. It is therefore essential that any manufacturer reviewing this option for code inspection is fully aware of performance and operation of any solutions offered.
Manufacturers must understand fully what the equipment is checking and exactly how the output of this check is providing conformance to specification.
Manufacturers must also understand completely the operating procedures and any checks / maintenance required for operation. Vision verification systems, when properly integrated can perform very useful process monitoring and in turn provide important process feedback that can be used for preventative maintenance scheduling.
However any verification system employed for final acceptance of Rolls-Royce components should be supplied with a certificate of performance ensuring compliance to the quality criteria laid out in the Rolls-Royce quality standards. The verification system should be fully demonstrated to meet this standard.



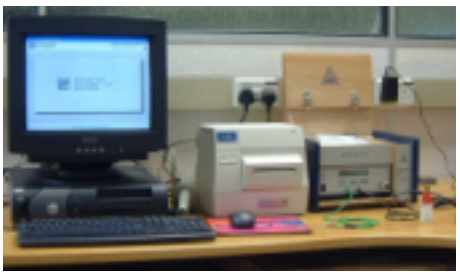
Other techniques for component verification or acceptance are through manual magnification methods.
It is not possible to verify a dot peen data matrix code to Rolls-Royce quality requirements using hand held reading equipment. Readability is a result of the process and is not necessarily a measure in the case of dot peen quality.

Electro Chemical Etching

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.



The process is fairly generic across most components and normally requires no fixture or holding device for operation. The Electro Chemical Etching marking process has been established for many years now but until recent developments of improved stencil generation techniques, the marking process has previously been limited to human readable data and some basic symbol information only.

When selecting a marking solution it is important to select an etching unit that is suitable for your particular application. Most applications will require a technique called combination etching. This basically means that any equipment selected must be capable of delivering direct current and alternating current etches automatically in the same cycle – preferably without manual switching. Many applications will require combination etching but this depends very much on the material to be marked. The stencil and the stencil generation techniques are also a key consideration when selecting an appropriate system.

There are 4 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 (not suitable for serialised part marking) but, although quality produced is good, the stencils maybe relatively expensive.

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.

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, 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.

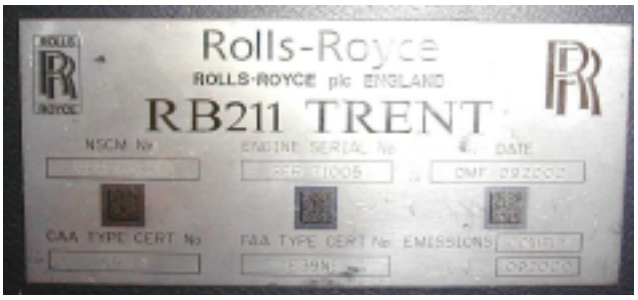
Electrolyte Solutions

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. Only Rolls-Royce approved electrolyte solutions are permitted for part marking operations.

Laser Part Marking

Laser marking is a process, which uses the thermal energy of the laser beam to vaporise, 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 many circumstances and these are identified in the appropriate Rolls-Royce quality standards. Laser marking can only be instructed by component definition.

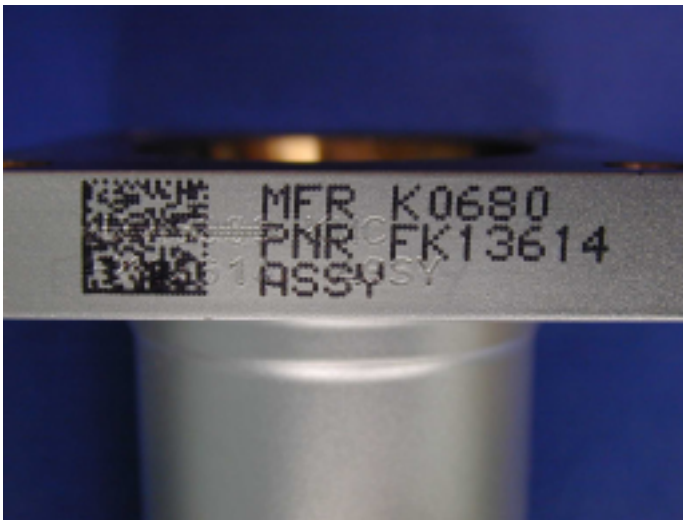


Manufacturers must consult the appropriate quality standards for full information.

Laser marking is a relatively new marking process for Rolls-Royce applications. It is essential for component manufacturers to understand their part material combinations and the necessary control and inspection procedures that are required to support the operation.
Laser part marking is unlike other marking methods in the fact that much of the quality acceptance criteria are based on metallographic assessment. Laser part marking quality is not accepted by visual appearance only; support from manufacturing laboratories will be required for this data card controlled process.

Ink Jet marking

Ink jet marking is normally required on painted parts due to the difficulties in reading or decoding identification marks through painted surfaces. The marking process precisely propels ink drops to the target surface with an extremely quick drying time – normally around 2 seconds.
The operation relies upon the movement of either print head or component to trigger the operation.



In most conditions – not all; the ink jet mark is regarded as a semi permanent mark as far as life cycle tracking is concerned. Its main use will be to support the initial build configuration checks and calculations required for operations like blade patternisation.
Selection of an appropriate ink jet marking system depends very much on type and size of parts to be marked. Where the parts can be easily handled and manipulated it may be more convenient to set up a printer head and apply movement through the part. Parts that are bigger may require hand held solutions where the print head is fixed in a handgun arrangement and movement is supplied through the gun operation.

The chosen system must provide clear consistent marking and this should be checked under magnification for dot placement accuracy. It is important to obtain process capability on actual parts (or test piece simulations) and not on a paper substitute where conditions are normally perfect.

Make particular note of any waviness in the mark as this will only produce problems later. Readability is important to check as painted parts will no doubt influence available contrast levels – depending on colour of paint/ink.
Neatness, uniformity and density of mark must all be satisfactory before the process can be accepted.

When applying ink to certain painted surfaces, to improve the ink performance there maybe a requirement to prepare the surface first with a thin lacquer to prevent ink bleeding. This can be assessed during testing.
All inks used for ink jet marking must be approved by Rolls-Royce.

Part Marking Quality Standards

The part marking quality standard for machine-readable code acceptance is specified by the component definition – no other standards must be used.

Format Requirements

The requirements placed upon Rolls-Royce and many other aerospace companies by the United States Department of Defence have necessitated some very important changes to our part marking standards. The use of International Organisation for Standardisation ISO/IEC 15434 syntax and coding of messages is fast becoming a commercial practice for high capacity machine-readable symbols related to part identification and is particularly favoured by military sectors and governmental authorities

To facilitate multi-faceted business applications the Air Transport Association have approved the use of ISO/IEC 15434 syntax 'wrappers' to be included with the long established practice of Text Element Identifiers.

The data encoded inside the matrix must now include the ISO/IEC 'wrappers'. An example of data inside a matrix for a serialised part is shown below.

[)>RSDDGSMFR 12345GSSER ABC123RSEOT

Below is an example of how the mark would look on the surface of the component. The human readable information is shown to the right of the data matrix but this position could vary depending on marking space available.

MFR 12345
SER ABC123

Legend:

[)> = A three character ISO/IEC 15434 compliance indicator

R_S = A format trailer character to indicate the end of a data format envelope. This is a special ASCII character 030.

DD = A format indicator which indicates that Text Element Identifiers are used.

G_S = A group element separator used between data fields. This is a special ASCII character 029.

E_OT = A message trailer which identifies the end of a message within a data stream. This is a special ASCII character 004.

The data above (MFR and SER) would under normal circumstances be captured in one data matrix code. This would then be supported by a second data matrix code that contains the part number only. An example of this is shown below

[)>R_SDDG_SPNR ABC123$R_S$$E_O$T

PNR ABC123

The layout for a non serialised part would carry data for MFR and PNR. An example is given below.

[)>R_SDDG_SMFR 12345G_SPNR ABC123$R_S$$E_O$T

MFR 12345
PNR ABC123

Code Quality

All machine-readable part marking is subject to code quality requirements. In summary, any part identification that does not meet this standard is subject to non-conformance authority assessment. If a code does not read at first build and during after service operations then it will add cost to the operation.
The quality requirements for code profile are contained in the appropriate Rolls-Royce quality standard.

Help !!

Direct part marking is a Rolls-Royce policy and a customer requirement. Many suppliers to Rolls-Royce may require further help and assistance with many aspects of implementing an appropriate solution(s) for machine readable part marking.
Help and advice is obtainable directly from Rolls-Royce on any aspect of Direct Part Marking implementation, equipment selection, quality requirements or operation assistance. This help and advice can be obtained through your Rolls-Royce representative or from the Rolls-Royce Direct Part Marking Team. Details are given below.

Team Leader Nat Russhard
Telephone 0044 1332 240209
07788 497398
e-mail nat.russhard@rolls-royce.com

Frequently Asked Questions

Q. What is Direct Part Marking?

A. Direct Part Marking is an international initiative supported by many industries worldwide and covers the implementation of machine readable coding of items. Marking parts directly is not always the preferred method of manufacture; some items are bagged and tagged but the ultimate method of identification is instructed by component definition.

Q. Why should I mark my parts in this way?

A. Direct Part Marking is a commercial practice and many Rolls-Royce customers are now demanding compliance with international quality standards.

Q. Who benefits from Direct Part Marking?

A. Everyone should benefit from Direct Part Marking. Direct Part Marking must be viewed as a process transformation that enables improvements in cost, quality and performance. Suppliers aiming for the 'tick in the box' for compliance are unlikely to benefit.

Q. Why is Direct Part Marking important to Rolls-Royce?

A. Direct Part Marking is a company policy and a customer requirement. The Rolls-Royce vision for Direct Part Marking is to facilitate item tracking in Rolls-Royce and customer business systems providing opportunities for business improvement and cost reduction through data accuracy and the removal of non value added activities.

Q. Surely if a code reads then it's acceptable, isn't it?

A. No. Code readability is a measure of the strength of a reader and not a quality measure we directly associate with Direct Part Marking. Readability is the result of many measures but readability as a sole requirement tells you very little.
It is important that manufacturers understand and apply suitable quality plans for Direct Part Marking applications; these could be sample inspection or full verification depending on the application.

Q. Will I need more than one Direct Part Marking solution?

A. It's possible that some suppliers will need more than one Direct Part Marking solution but this depends on the types of components and component definition.

Q. What should I do next?

A. Rolls-Royce suppliers should familiarise themselves with the Direct Part Marking quality requirements and review the number of components they deliver to Rolls-Royce. It's probably best to place these in families of parts by shape and position of mark. This exercise will quickly show the types of Direct Part Marking solutions required. Further help and advice is available.

Q. How much space does the mark take up?

A. The mark size depends entirely on the selected cell or module size and the amount of data to be encoded. This information is provided in tables that can be found in the Rolls-Royce quality standards.

Q. What needs marking and what doesn't?

A. Parts that require machine-readable codes are normally classed as end items. These are engineering part numbers that are built into the engine and constitute the Bill of Materials. In general this will apply to every engineering part number. Parts that do not need to be marked in this way are detail parts that form part of a non-separable assembly, forgings and castings and any national standard type part.

Q. Are drawing alterations required?

A. Not normally. Drawing alterations are required where a change to the permitted manufacturing process is required or the mark location needs to be moved. In these cases drawing alterations must be submitted and approved before work can proceed. If in doubt contact your Rolls-Royce representative for advice.

Q. Should I use 1D or 2D bar code processes?

A. The normal method will be to mark parts with the 2D data matrix methods outlined in this document. However some labelling techniques will use the 1D coding process due to representing little or no change.

Q. Can I select my own marking parameters and layout?

A. Within reason Yes. The format and data content is very much instructed through the quality standard but some flexibility does exist. Guidelines for marking parameters are also specified in the quality standards but providing the intent of these are met then code size is very much left to the manufacturer. Where laser part marking and electro chemical etching is concerned then these are data card controlled and adherence to this procedure is mandatory.

Q What information do I mark on the part?

A. Direct Part Marking requires that final part marking is must meet the machine readable requirements. This means that manufacturers will mark the following as a minimum.
MFR – This is the design responsibility for the part and will normally be a Rolls-Royce Cage code. Ask for further details.
SER – This is the unique serial number of the part and this MUST be unique within the cage code. Control and issue of serial numbers is critical.
PNR – This is the part number assigned by the design engineering authority.

Q. Can I put all of the information in one data matrix?

A. Not if the part if serialised. Serialised parts will 'normally' require 2 data matrices. One will contain MFR and SER information and the other will contain PNR data.

Q. Can I place more data in the code?

A. Yes. It's advisable to take further advice here as the data structure and format are essential for decoding and transposition. The component definition may instruct additional requirements also. This should always be checked.

Q. Can I sub contract the marking operation?

A. Yes. Part marking can be sub contract but this must be to an approved manufacturing supplier.

Q. What is Text Element Identifier (TEI)?

A. TEI's are 4 character codes that prefix given data. The codes are 3 alpha codes followed by a space. These codes identify data making it intelligent for IT systems further down the part manufacturing, build or after service cycle. All TEI's must be recognised and approved for use by Rolls-Royce before introduction.

Q. Will Rolls-Royce support my capital costs?

A. Rolls-Royce will not support additional capital costs for Direct Part Marking implementation. Rolls-Royce is investing well over £10M in its own factories world wide.

Q. Can I utilise my existing equipment?

A. It is possible and likely that some existing equipment can be modified and or upgraded to meet the requirements of Direct Part Marking. This information can be obtained through the equipment manufacturer / supplier.

Q. Does this increase the price of the parts?

A. In short no. Direct Part Marking is fast becoming a commercial practice and all engine and air frame manufacturers will be required to comply. Rolls-Royce will not be charging its customers for items that have Direct Part Marking identification.

Q. Will I require a part number change to implement Direct Part Marking on existing parts?

A. No. Part number changes will not be required to change the marking process. Drawing alteration will only be required when changing marking processes or mark location. Some classified parts may require Method Change Control Approval (MCR).

Q. How do I inspect the quality of the mark?

A. Data matrix quality checks are required for data content and accuracy and code profile or appearance. The data content can only be verified by de-coding the mark using a reader capable of this operation. The profile or appearance of the code can be inspected under magnification or by vision verification. When selecting to use vision verification the manufacturer must be satisfied on the operational requirements of the verifier and the integrity of the checks that it is performing.

Q. When will Rolls-Royce require me to start applying machine readable identification?

A. Rolls-Royce requires that all suppliers plan for immediate implementation and this is instructed by Notice To Supplier 145.

Q. Can I still use Vibro peen?

A. Vibro peen can still be used where permitted by component definition. However final part identification (Manufacturer MFR, Serial Number SER, and Part Number PNR) can only be carried out by a capable process. Vibro peen is not capable of 2D data matrix identification.