DIRECT PART MARKING

THE NEXT GENERATION OF DIRECT PART MARKING (DPM)

Direct Part Marking (DPM) is a process by which bar codes are permanently marked onto a variety of materials.

The DPM process allows for marked materials to be tracked throughout their lifecycle, especially products slated for use in harsh environments.

DPM is used in a variety of industries, such as automotive, aerospace, weapons, manufacturing and electronics. Additionally, some national departments of defense demand physical marks to be embedded on certain assets.

DPM has been successfully used on many different types of material, ranging from hard materials like metal, plastic, and glass, to soft materials such as rubber and leather. The parts being marked can be as large as the engine block of a car, or as small as a medical instrument or fine jewelry.

DPM SYMBOLOGY

The most common barcode symbology to use with DPM is DataMatrix. This is an industry standard, first codified by AIAG (Automotive Industry Action Group). Specifically, the ECC 200 subtype of DataMatrix should be used. Why? The ECC 200 DataMatrix (a 2D or 2 dimensional bar code) marks utilize the Reed-Solomon Error Correction algorithm, which provides a predetermined and predictable amount of error correction capability. Error Correction capability is especially important in DPM applications as the objects being scanned are often naturally finished in rough surface conditions, marred by dirt, rust and other contaminations, and subjected to severe environments, abrasive working conditions, and/or rough handling. The superior error correction ability provided by ECC 200 allows DataMatrix barcodes with severe damages to be decoded.

If the part to be marked is cylindrical in shape, it may be better to choose a rectangular DataMatrix, and to align it so that the longer direction is parallel to the axis of symmetry. Most bar coding software/hardware automatically generates square DataMatrix barcodes, but is also capable of generating rectangular DataMatrix if so specified.

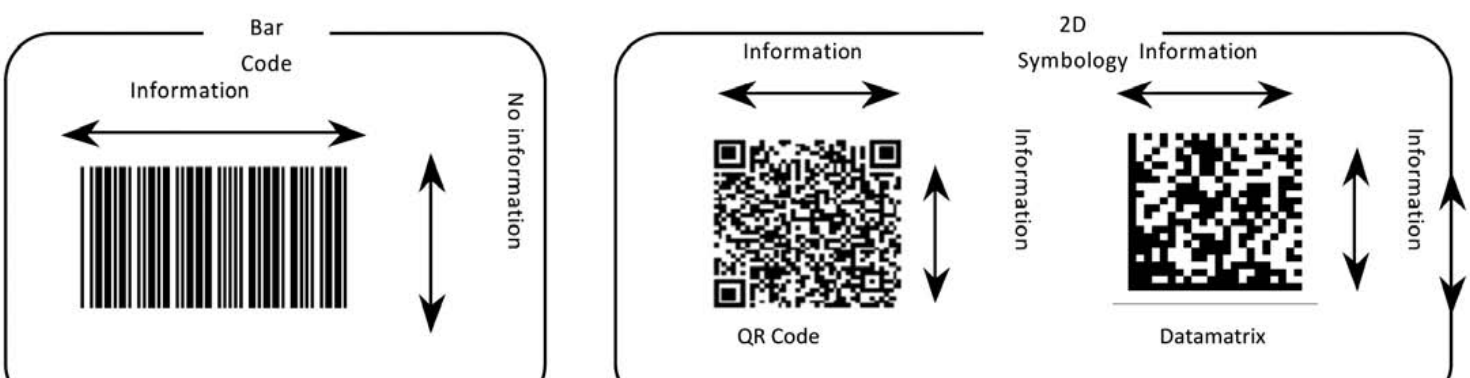
WHY 2D BAR CODES?

- Consume less space
- Have built-in error correction (100% data recovery with 15 to 20% damage to symbol)
- Have large data capacity (hundreds of data characters are possible within each code – see figure below)
- May be printed on paper labels to affix to a surface or as directly applied marks (e.g., laser etched onto a surface, peen stamped onto a surface or ink jetted onto a surface)

Due to their small size and the amount of data that can be stored on them, 2D bar codes can enable manufacturers to:

- Provide traceability - for the primary purpose of precisely identifying manufactured items involved in a spill or potential field action.
- Provide verification and error proofing - the capability to validate correct part/component/module/assemblies
- Provide part identification - the capability to identify part/component/module/assemblies

2D CODES CAN CAN HOLD LARGE AMOUNTS OF DATA BY CARRYING INFORMATION IN BOTH HORIZONTAL AND VERTICAL DIRECTIONS

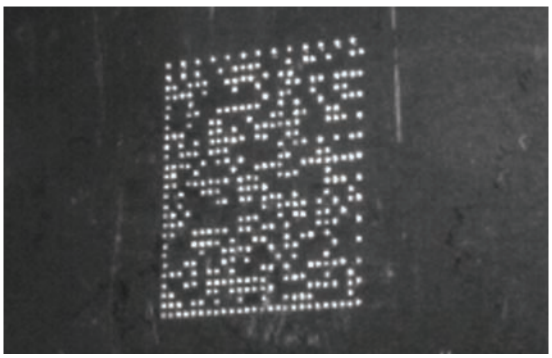


Symbology Type	2D Symbology	Bar Code
Data Type	Alphanumeric, Binary	Alphanumeric
Data Capacity	Approx. 2,000 characters	Approx. 20 characters
Data Density	20 to 100 times	1
Data Restoration	Yes	No

DOT PEENING

A dot-peen machine uses a sharp tool (the peen) to score on the part being marked repeatedly, at precise locations. Each module to be marked is represented by an indent on the part.

Dot-peening is especially suitable to marking metal parts. The peening of a metallic object does not break the metallic bonds between atoms; rather, it only deforms the bonds, and possibly increasing their strength. An example of a peen mark is shown below.



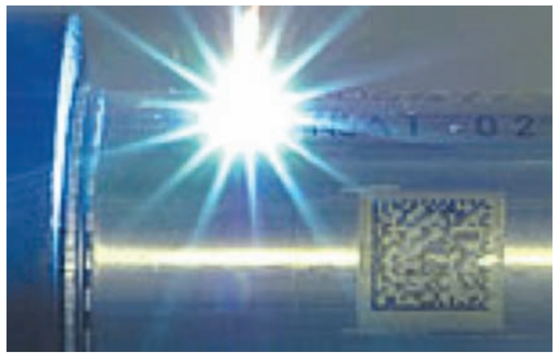
LASER MARKING

Lasers can also be used to create marks on some materials. This is done by directing a beam of coherent, collimated, focused light energy onto an item's surface. In general, when a laser's beam comes into contact with an item, its light energy is converted into heat energy, which creates a mark either by melting, ablation, carbon migration, or chemical reaction. Various materials may react differently to each type of laser and/or laser marking technique. All lasers will not create readable marks on all substrates.

When considering a laser marking system, the following factors should be taken into consideration:

- The type of material to be marked (laser etching is most commonly used on electronic components and on metal medical devices)
- The laser type and marking process type
- Laser power
- Cycle time
- Information (volume of data) to be marked
- Laser safety

Different materials absorb or reflect specific laser wave lengths at different rates. The amount of absorption is directly proportional to the laser's ability to heat the material and cause a change in its appearance. The type of lasering medium will determine a laser's light wave length. Laser marking systems typically derive their name from their lasing medium. For example, CO2 lasers use carbon dioxide gas as a medium. Laser marking generally produces the fastest marking cycle. An example of a laser mark on stainless steel is shown below.



The marking parameter that affects the decode-ability the most is the pitch. This is distance between nearest modules. When choosing the pitch, one should consider the surface roughness of the part to be marked and the accuracy of the marking device. With rougher part surfaces, and/or less accurate marking device, the pitch should be chosen larger, in order to avoid ambiguities. (Sometimes people use the term "module size" to refer to the pitch. While these two values should coincide for DataMatrix printed on paper—and even then they may not be the same due to an effect commonly referred to as "ink spread", in DPM they are generally very different.)

When the part surface is rough, it is sometimes advantageous to mark it with a sharp peen (one with a smaller cone angle), and to scan it at a large off-axis angle. This helps the scanner to distinguish between features created by the marking process from those that existed originally before marking.

Sometimes it is necessary to paint a part after the marking process. If this is the case, the marks may need to be created with larger pitch and depth, so that the marks are not completely covered up by the paint.

To benefit from the widest range of DPM scanners, it is beneficial to choose the pitch value to be not too large, nor too small, such as in the range of 6.7-20 mils. Some scanners that scan DPM in this range of pitches can scan normal-sized paper barcodes, providing efficiency and economy at the same time.

MARKING GUIDELINES

- Data elements must be larger than the surface irregularities
- Marking surface dictates minimum cell size
  - Different for every surface condition – it is important to note that there is no definitive set size for the materials intended to be marked with DPM – the general rule is to create a mark as large as the size your material will permit.
  - Similar for different marking techniques
- Consider marking cycle time - cycle marking time for better quality applies only to laser marks. Generally longer marking time may mean a better mark but that may not always be the case. Too long a cycle time may burn or destroy a surface. Too short a cycle time on a specific surface may make a mark unreadable.
- Others – it is important to take other marking guidelines factors into consideration, such as ensuring there is proper contrast between the actual mark and the material that is being marked – marks should be clearly defined so they can be easily and efficiently decoded. Another factor is to ensure the code is as visible as possible to enable a successful decode – a good practice is avoiding creating marks too close to the edge of the material being marked as much as possible.

CONSIDERATIONS

The following are typical criteria for using DPM

- The part is too small to be labeled with traditional bar code labels
- The part is subjected to environmental conditions that preclude the use of labels
- DPM may be more cost efficient than individual item labels
- Identification is required for the life cycle of the part and labels are not acceptable (for the reasons stated above)
- DPM is integrated as part of the manufacturing process rather than a secondary or manual process

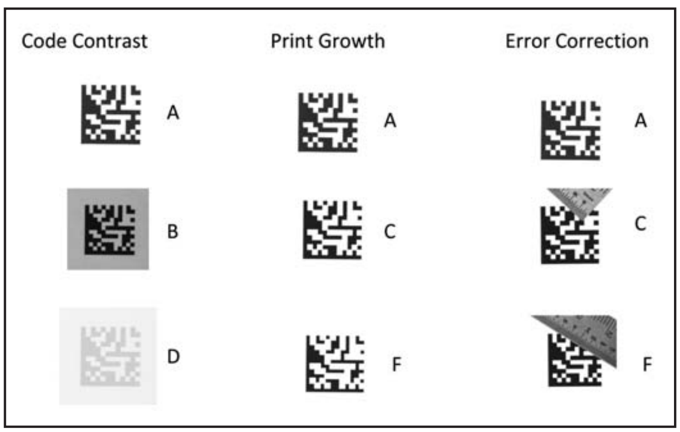
WHAT ARE SOME DRAWBACKS OF DPM CODES?

A 2D code is difficult to read

The **MOST** common issue when a 2D code is difficult or hard to read is that it is not printed properly.

In this case, end users typically blame the DPM reader, but in most cases the real culprit is the code itself.

The best way to determine if a code is properly printed is to use a DPM verifier to grade the code to determine its quality. A DPM verifier is a system consisting of lighting, optics, camera (imager), verification software, and calibration references. The resolution of the verification system should be at least twice that of the imager (reader). This may be accomplished with either higher magnification optics or an imaging device with twice the resolution of the reader. As a good practice, DPM systems should require verification immediately following the creation of the mark to maintain quality and downstream scan-ability. When encountering a hard to read DPM code, the best way to determine its readability and repeatability is to get a verifier and grade the code. Verification grades fall between A, B and C (good readability) to D, E and F (difficult to read). The verifier looks at a number of criteria when determining a grade. These examples of grades and criteria are shown below.



TIPS TO ENSURE GOOD DPM MARKS

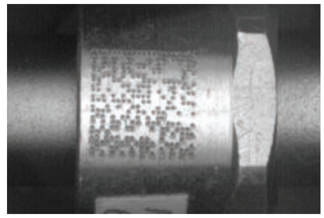
1. To allow for the best possible imager performance, it is best to use the largest practical size element/cell dimension that fits within the available area.

2. Make the 2D symbol as large as practical, not as small as possible. As symbol element/cell size decreases printing/marking and scanning/imaging issues increase exponentially.

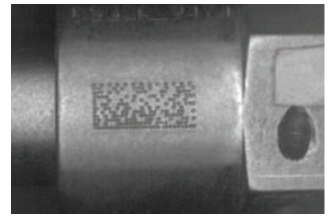
3. Datamatrix reading requires a quiet zone in an area around the entire perimeter (all four sides) with a quiet zone size larger than the size of an individual element within the code.

4. For marking and reading, flat surfaces are preferred over curved surfaces. The curvature of an item may prohibit proper labeling or marking and may distort the code to the point that it cannot be decoded. If the label or mark is on a round/curved surface, the symbol height SHOULD be < 16% of the part's diameter.

GUIDELINE MARKING DPM ON A CURVED SURFACE



IMPROPER MARKING



PROPER MARKING

THE 2D CODE GRADES WELL, BUT IT STILL CANNOT BE READ

If you have a DPM code that you are having problems with but still can't read it dependably, it is possible that the operator is at fault. It is important to remember that DPM is NOT like a barcode label. On a paper label a 2D code usually has black dots printed on a white surface which makes it easy to read. A 2D code printed on a non-paper surface has all kinds of issues that make it harder to read than a label. Among these issues are:

2D Code Marked on Rough Surface
Solution: Read at an angle and at a distance far enough that the imperfections are not interfering or as an option on laser marked items, mark the 2D code after first performing a "clean up pass" with the laser to remove surface imperfections.

2D Code Marked on a Shiny Reflective Surface
Solution: Read the code in a way so that other light sources and the reader do not cause the 2D code to be washed out by unwanted lighting. First look at the code with your eyes to try and see if ceiling lighting or outside lighting cause a "light bar" to reflect back from the source effectively rendering the visible code from being seen. Minimize or eliminate this effect by eliminating these reflections. Adjust your reader position so that it is at angle that will not cause another reflection from the readers light. Reflections back to the reader from the reader lighting itself causes "blinding" and prevents the reader from seeing the 2D code.

Focal Distance is too Close or too Far for Reader to Read the Size of 2D
Solution: Start with the reader closer to the 2D code and slowly move away until focus is correct and the 2D code reads.

Trying to Read the 2D Code at too Great or too Small an Angle
Solution: Start with an angle that is about 75 degrees to vertical and slowly move toward an angle of about 30 degrees to vertical (closer to parallel) while pulling trigger at each position. If you have proper focus the code will likely read.

Surface Imperfections Showing at Certain Angles Degrades or Hides the 2D Code from the Reader
Solution: 2D codes marked on a surface where machining marks create small long lines of imperfection can be very difficult to read. Light from a reader bounces back off these lines when presented at an angle that is perpendicular to the grooves. Turn the part at an orientation where the grooves are parallel to the reader lighting. This hides the grooves as the lighting does not bounce back to blind the reader, rather it simply renders the grooves invisible to reader since the lighting does not reflect back.

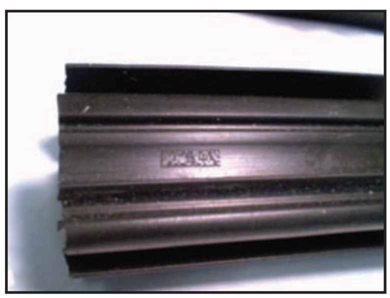
Not Enough Lighting to Enable the Reader to Effectively "See" the code
Solution: There are times when the reader does not elicit enough illumination to effectively allow the reader to see the code. In these cases it may be necessary to add external lighting to the reading surface to provide enough contrast for the reader to see the code. Sometimes ceiling lighting alone may help. Other times you may have to add external focused LED lighting.

Peen Marked Codes that are Painted over are Hard to Read
Solution: Painted over peen marked codes that have good depth are easy to read regardless of the color of the paint covering the code. A low attack angle with the reader causes light from the reader to "bounce off" the non-marked surface and to "reflect back" over marked surfaces (the dots). The reader sees what we call "dark field illumination" on the surface which means surface is dark and the dots reflect back light, which the reader sees as white dots. With this method, it is very easy to read a completely black painted over peen mark if there still are depressions on the surface where the dots are.

MARKING EXAMPLES

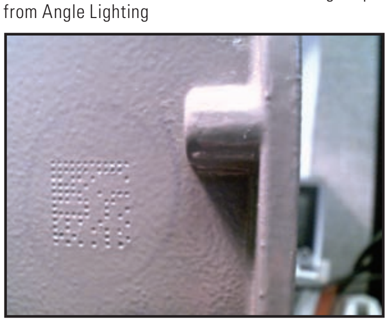
Laser Mark on Rough Surface

Laser Mark on Rubber

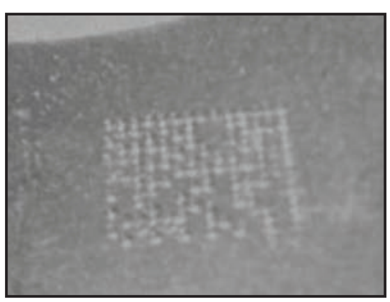


Peen Mark on Cast Surface

Painted Over Peen Mark Shows How Dots light up from Angle Lighting



Peen Mark on Hard Plastic



Rectangular Laser Marks on Shiny Curved Surface

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