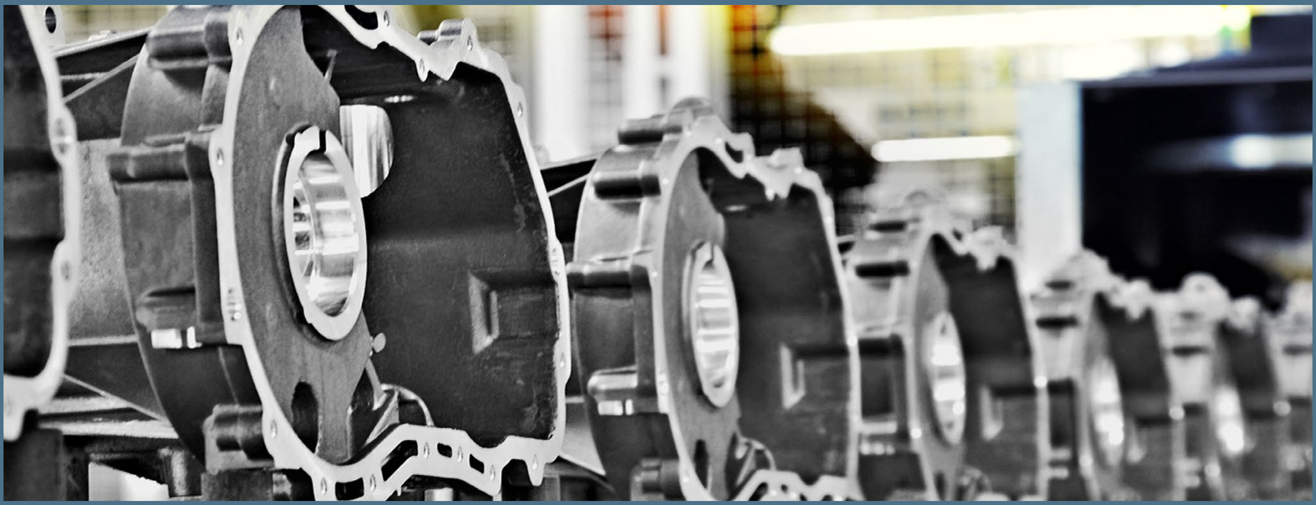
Technical guide

Methods for direct part marking

Machine-readable identification for the automotive and aerospace industries



The practice of Direct Part Marking (DPM) is used across many industries to identify an array of end use items. This process, also referred to as machine-readable identification, is prevalent in the automotive and aerospace industries for marking alphanumeric and 2D DataMatrix codes on individual parts and assemblies.

This technical guide provides a comparative evaluation of the most common marking technologies used for DPM including laser, ink jet, dot peening and electrochemical etching. For additional information on encoding and code verification, see our whitepaper entitled, "*Implementation of direct part marking identification*."

Contents

Direct Part Marking, the new standard in parts coding

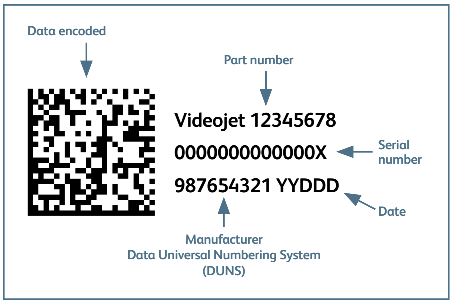
DPM standards have been adopted by a number of associations within the automotive and aerospace industries. Marking parts with machine-readable codes allows for a part to be tracked throughout the manufacturing process and the supply chain.

Manufacturers can use DPM to track parts throughout the manufacturing process and supply chain. It is ideal for locating parts for service or recall and can assist in liability and warranty resolution.

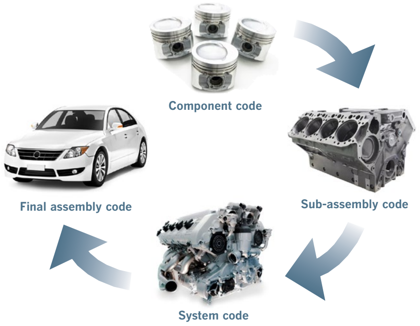
In parts production, the use of machine-readable codes can help reduce the need for manual code entry, increasing code accuracy and speeding-up data exchange. Electronically generated codes that include both 1D and 2D bar codes offer simple data storage and usage for internal IT systems. For over 20 years, the 1D bar code has been widely used for data delivery, but this format is being replaced with 2D formats. This is because 2D codes are able to contain more information in less space and can be applied with a variety of direct marking methods.

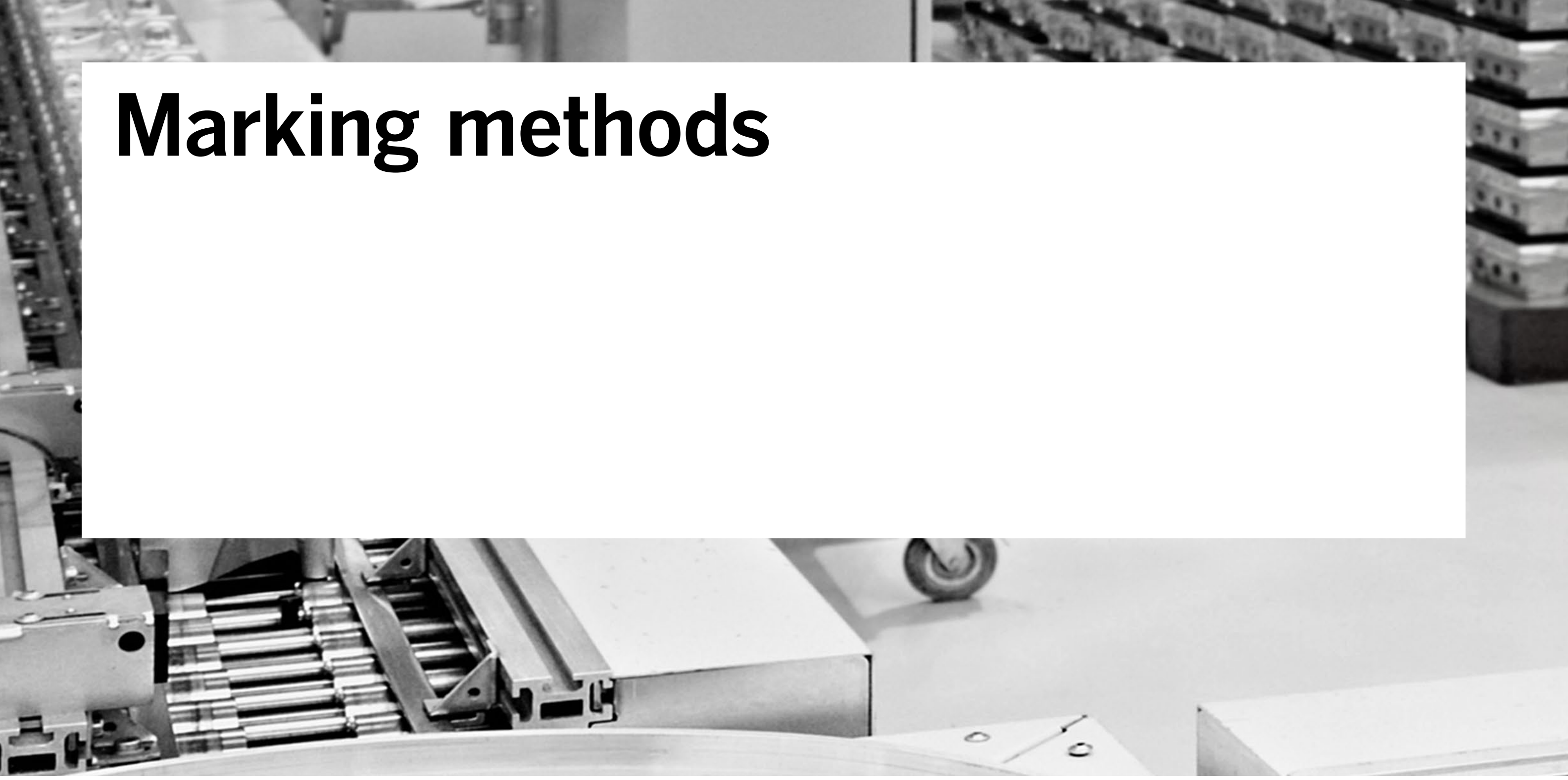
The three main elements in DPM are encoding, marking and verifying. Encoding is the rendering of a string of data into a pattern of dark and light cells that includes data, padding and error correction bytes to then be used by the marking device. Marking is the imprinting of content directly on your part with the appropriate technology for the substrate. Verification is the act of confirming code accuracy and quality. This is most commonly performed immediately following product imprinting at the marking station.

Example of a DPM code



Full life cycle traceability





Marking methods

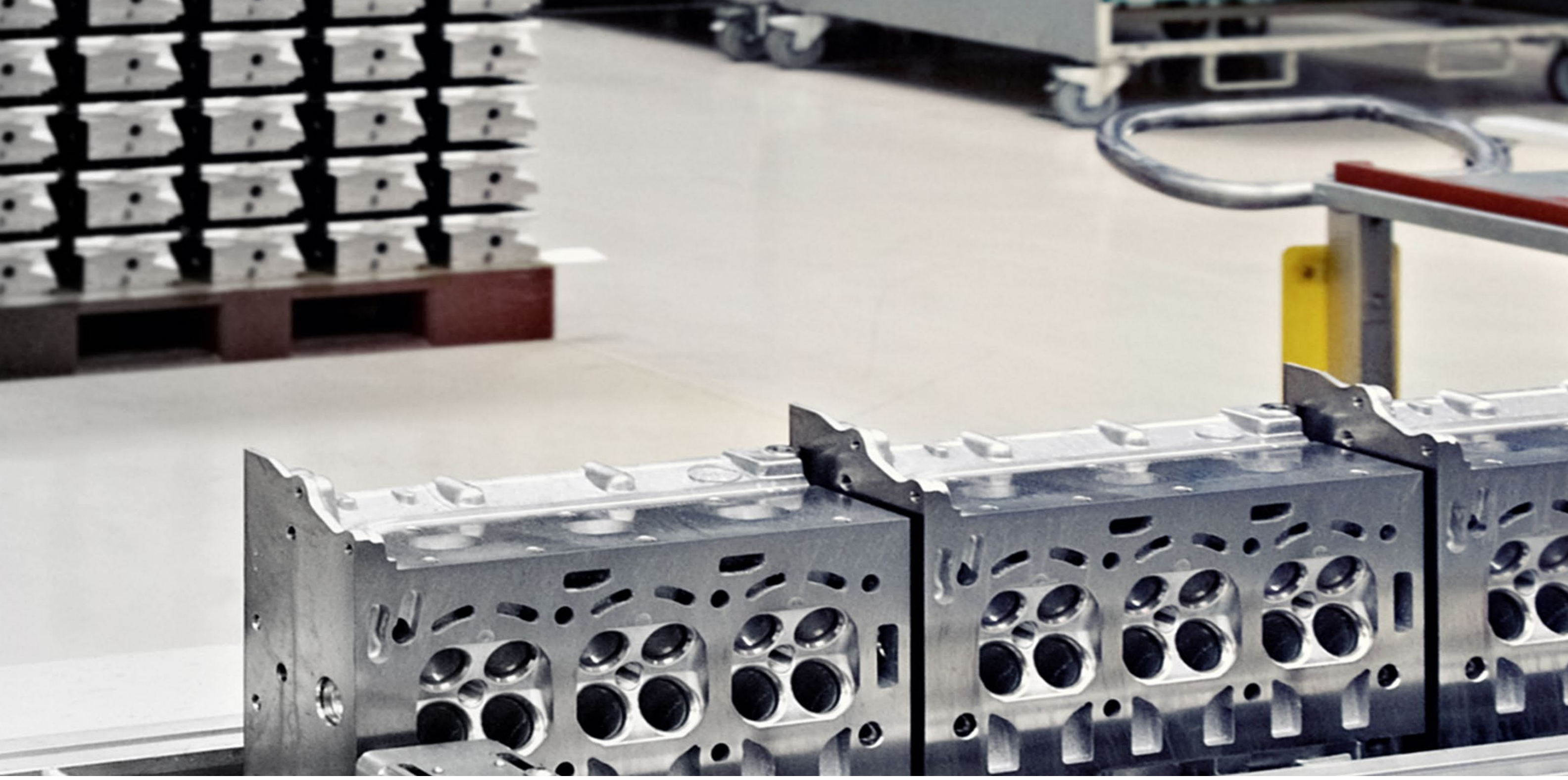
Aside from selecting code formatting and content, it is also important to consider the best method for marking the part. The benefits of DPM are typically greater than that of other options, such as label application. However, the physical characteristics and make-up of the part can also result in marking issues for manufacturers.

For the automotive and aerospace industries, the most common coding methods are laser marking, continuous ink jet printing, dot peening and electrochemical etching. When comparing these marking technologies, it is important to focus on the material to be marked, the flexibility of the process, cost factors, speed, throughput and opportunity for automation of the marking process.

DPM can be used on a wide variety of materials, but each substrate has unique aspects such as roughness of the substrate, ability to withstand thermal stress, and fragility of the material being marked.

Printing technology and substrate suitability

		Aluminum	Copper	Titanium	Iron	Steel	Magnesium	Ceramic	Glass	Synthetics
Laser	**CO_2 laser**								•	•
	Solid state laser	•	•	•	•	•	•	•		•
Continuous ink jet		•	•	•	•	•	•	•	•	•
Dot peening		•	•		•	•				•
Electrochemical etching		•	•	•	•	•	•			



Common marking options comparison

	Laser	Continuous ink jet	Dot peening	Electrochemical etching
Flexibility Print on difficult surfaces, distance between part and marking device	High	Average	Average	Low
Investment/initial outlay	High	Average	Low	Low
Ease of integration Ease of communicating with a Programmable Logic Controller in production cell and space needed for installation and maintenance	High	High	Average	Low
Type of marking method *Non-contact* (part is not touched by marking apparatus) *Contact* (part is touched by marking apparatus)	Non-contact	Non-contact	Contact	Contact
Abrasion resistance of mark	High	Low	High	High
Mobility Ease of moving marking equipment to other locations on the production line	Low	High	High	High
Thermal or chemical stress	Yes	No	No	Yes

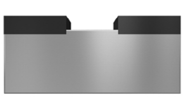
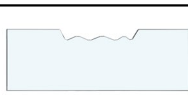
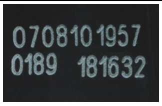
Laser marking

Laser technology is a popular solution for providing permanent codes on parts. Laser marking systems apply clear, high-quality codes in a wide range of production environments. Marks are applied using heat instead of ink, so lasers are often considered to be faster, cleaner and require less maintenance than other coding systems.

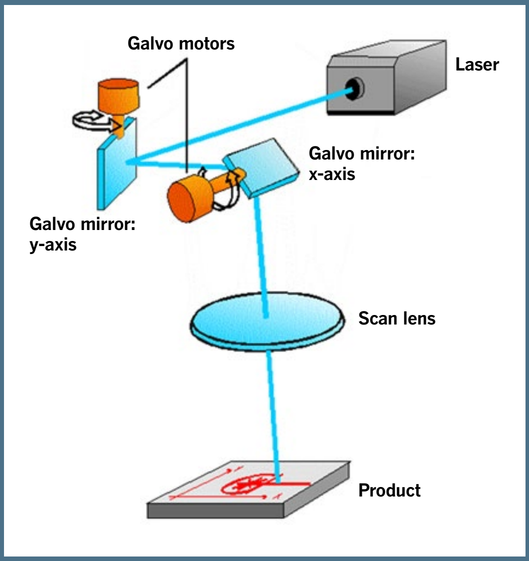
Laser marking systems can generate high quality marks including linear and 2D codes, optical characters, and alphanumeric messages on a range of substrates. Variations in specified wavelength, marking head and chosen lens will result in different marking effects on a given substrate.

Laser mark effects can vary. Color change is the result of a chemical reaction between laser and product. There is also engraving of the surface, ablation or color removal of the surface coating to reveal an alternate color underneath. Moreover, there is carbonization or controlled burning of wood or board-based materials. And there is melting of different plastic materials to achieve either a raised or concave effect.

Laser marking methods

	Illustration	Description	Materials	Sample
Ablation		Removal of the top layer of a substrate, normally painted, by vaporizing the paint.	Cardboard, plastic, glass metal	
Engraving		Deeper material removal that generates a depression in the material.	Plastic, metal	
Tempering		Substrate reacts to the laser beam of a certain wavelength by changing the structure formation.	Plastic	
Change in color/ bleaching		Change in color where laser touches the surface of the substrate.	PVC, metal, plastic, foil	
Inner-engraving		Internal color removal without affecting the top layer laminate.	Glass, plexiglass	
Fracturing		Material reacts to the laser beam by generating micro breaks on the surface.	Glass	

Laser technologies for marking parts include gas laser, such as CO_2, and solid-state lasers such as YAG or fiber. Gas lasers are especially suitable for marking synthetic substrates and glass. Solid-state lasers can mark almost any kind of material, and fiber lasers provide extra advantages of a small footprint and long service life.



CO_2 laser technology diagram

Evaluating laser marking systems

Laser systems offer a very flexible method to mark products, which can also mean a high level of automation in the production process in many industries. Laser is a great choice for fast speeds and low maintenance. Advanced laser producers offer larger marking fields that can mark multiple parts without reorienting the laser or tray of components, which helps to improve output. A large marking field also helps optimize power settings.

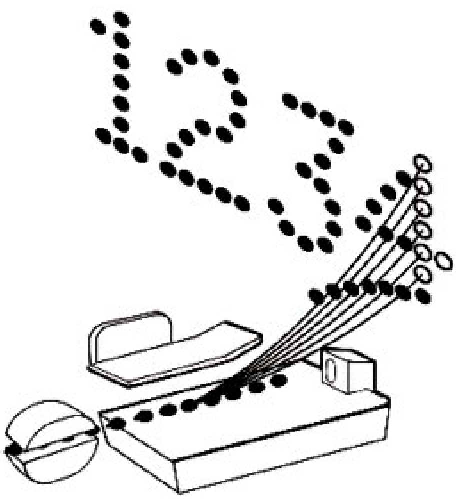
Not all laser marking systems are equal, and expertise can go a long way in helping you specify the correct laser for your line. It is recommended that you work with a coding partner that offers a large selection of laser configurations. This enables you to more easily identify and integrate an optimal solution for your needs, and not over-purchase more laser than you need for your application.

Advantages and disadvantages of laser marking

Laser marking delivers very precise marks on a wide variety of substrates, allowing for a high level of flexibility and readability. Shown to be faster than dot peening, continuous ink jet and electrochemical etching, laser can also help to increase throughput and efficiency in high volume production environments. Also, since there are no consumables, operating and maintenance costs can also be reduced.

When using laser marking systems, the material being marked is exposed to thermal stress, which may compromise the integrity of the part. A safety procedure to install a beam shield should also be performed in order to contain your laser and protect your operators.

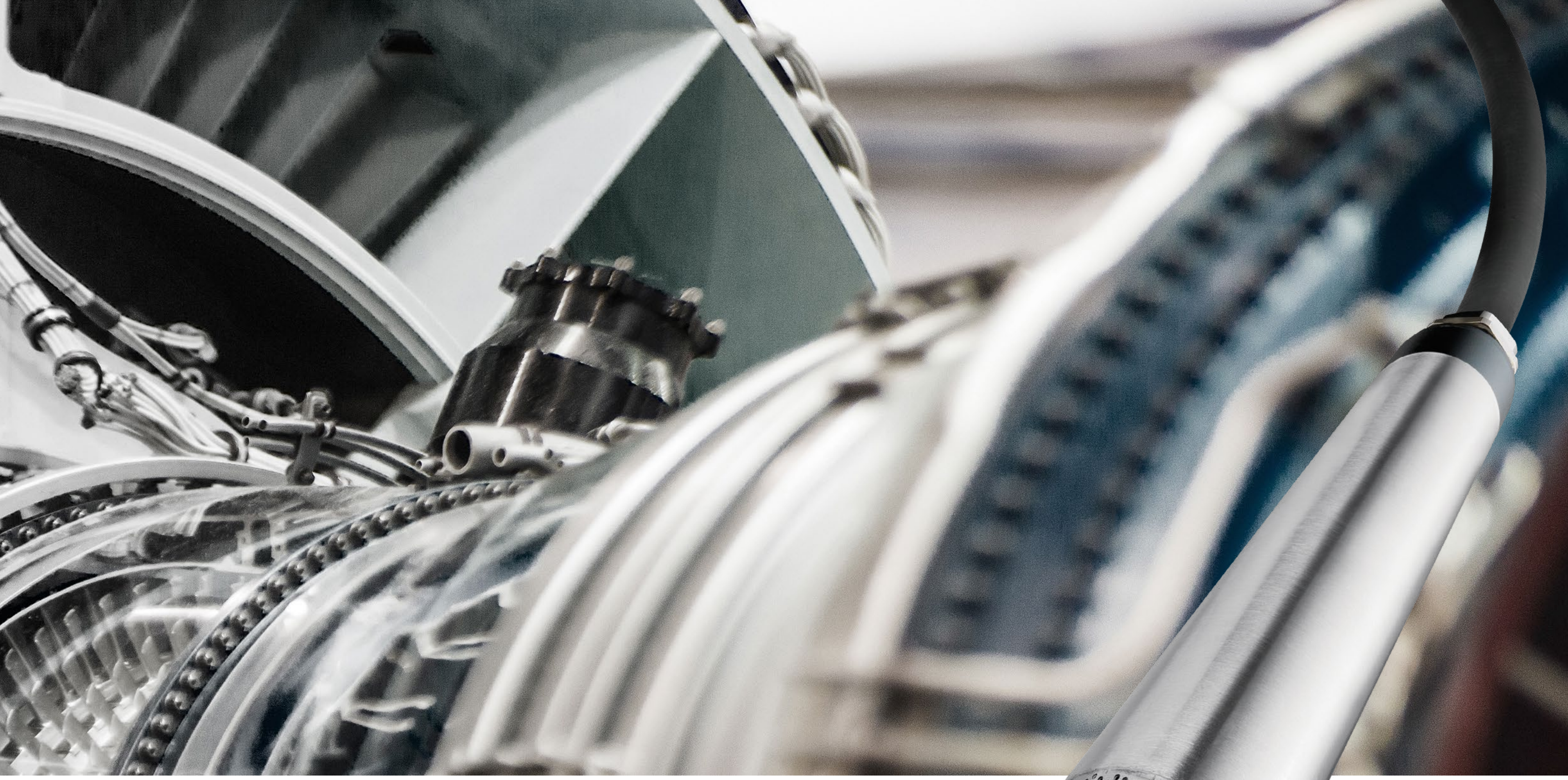
Continuous Ink Jet (CIJ)



CIJ technology diagram

CIJ printing provides non-contact coding on a wide variety of products. With CIJ technology, a stream of ink drops is delivered to the print target via a printhead. The ink jet comes out of the printhead through a nozzle and an ultrasonic signal breaks the ink jet into tiny drops. These individual ink drops then separate from the stream and receive a charge that determines their vertical flight to form the characters printed on the product. CIJ printers deliver legible printing on nearly any surface, smooth or irregular, and can apply codes on the side, top, bottom or even the inside of a product. They are ideal for convex, concave, irregular, as well as very small or hard-to-reach surfaces where a non-contact printing method would work well.

CIJ is an ideal technology for printing DataMatrix codes as the distinctly formed drops used to create such codes provide excellent readability. Industrial ink jet printheads can also be positioned farther away from the marking surface and still deliver clear, clean codes. Initial investment for a CIJ printer is usually lower than for laser and it can print on a wider variety of materials depending on the ink selected. These printers also offer high marking speeds and can be specified with automated features that can help ensure the right code is marked onto the right product.



Evaluating CIJ printers

CIJ printers produce simple lines of code and are ideal for automotive and aerospace parts marking. They are cost-effective for low-to-medium volume producers and are easily integrated into existing production equipment. CIJ inks are fast-drying and can accommodate both high-speed and lower volume production environments. CIJ technology is also non-contact and will not damage or compromise the surface of the part.

Advantages and disadvantages of CIJ

Ink jet printing generally offers a low initial investment and can print on a wide range of substrates adding to the technology's flexibility. The fast printing speeds available can also help to increase throughput.

Conversely, there are considerations with ink jet printing such as making sure the product to be marked is clean so that the code will be clear. This can add steps and time to the production process and in some cases, add cost, if special cleaners are needed. Ink jet codes, while durable, may not withstand the same abuse as codes made with laser marking or dot peening. Most of them can also be removed with certain solvents.

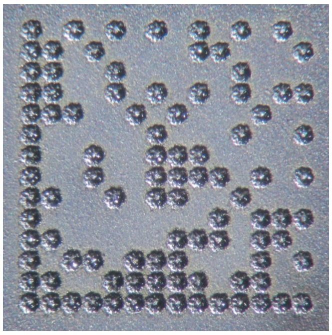
Dot peening and electrochemical etching

Dot peening

Two other marking types common in the automotive and aerospace industries are dot peening and electrochemical etching. In dot peen marking, an indenting pin is used to create an indentation for each dot in the DataMatrix code. The contrast needed for accurate verification comes from the light that reflects differently on the indentations and the surface of the product. In some cases, one code dot is represented by four indentations that are positioned very close together, resulting in larger code dots that appear to be almost square in formation.

Advantages and disadvantages of dot peen marking

Dot peen marking generally requires a low initial investment and provides permanent marks. Because it is simply indenting the surface, this technology is not known to damage or compromise the integrity of the product being marked. However, there are on-going expenses to maintain and replace indenting pins because of the wear and tear that these pins endure during the marking process. In addition, some thinner products may not be suitable for dot peen marking, as there is not enough substance to indent without piercing the material.



Electrochemical etching

Conversely, electrochemical etching removes layers of material via electrolysis. This chemical etching process takes an image on a stencil and transfers it to an electrically conductive product by the action of electrolyte and electricity. The chemical etch marking process has the advantage of being easy-to-use and inexpensive, while still giving a high-quality mark. This process offers a high resolution black "oxide" or "etch" mark and it is suitable for both soft and fully-hardened metals.

Advantages of and disadvantages electrochemical etching

Electrochemical etching provides very precise marks, allowing for high readability of codes. It offers excellent performance on very hard metals and has the lowest investment cost of the technologies commonly used for part marking. However, this technology can only be used on metallic, conductive materials, so it has limited flexibility as to the types of materials it can mark. Pre-formed molds are needed for each code, further limiting the flexibility of this technology.

The bottom line:

Direct part marking is essential to full cycle traceability throughout the manufacturing process and supply chain.

A global leader in coding technology, Videojet understands lean manufacturing and the complex demands of direct part marking. Each production environment and product substrate is unique and requires special consideration with the selection of a coding technology.

With the move in the industry to 2D coding, manufacturers are transitioning to laser or CIJ printing. Unlike some coding providers in the Automotive and Aerospace industries, Videojet offers a wide range of technologies, including laser and CIJ, helping to make selection of the right solution easier than ever. In fact, many top OEMs and part suppliers already trust our coding specialists and service engineers to help them identify, integrate and maintain the right coding solutions for their production lines and cells. This expertise, combined with outstanding products can help you sustain your nearly non-stop production, even in challenging environments.

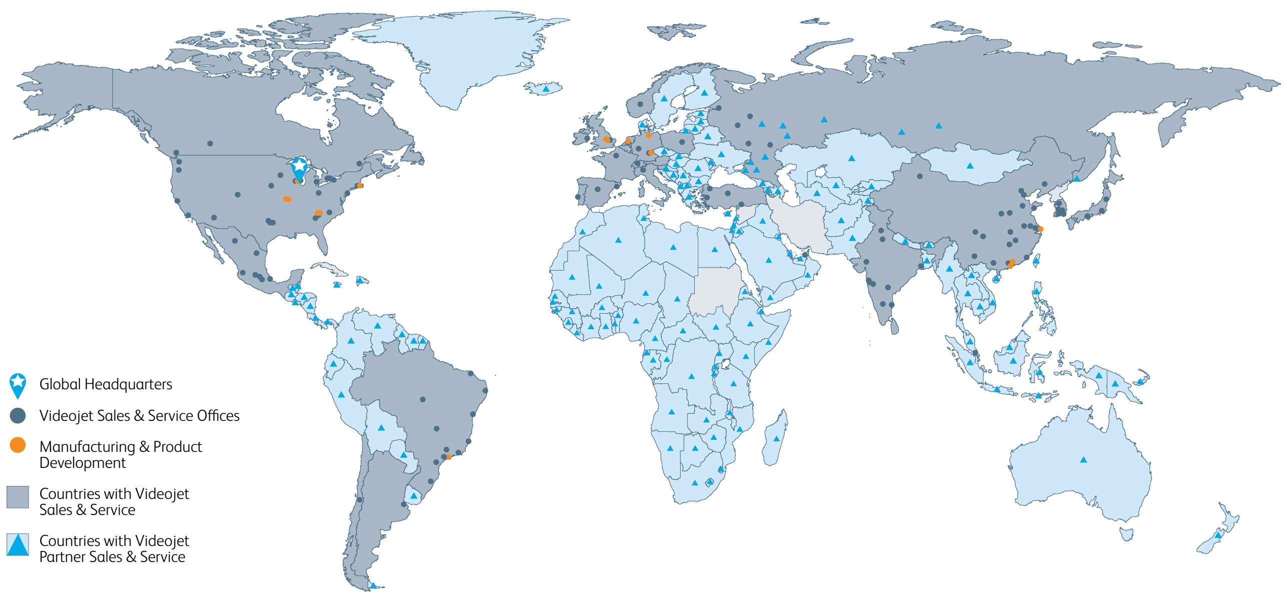
Trust the expertise of a global leader in product coding. Trust Videojet.

Peace of mind comes as standard

Videojet Technologies is a world-leader in the product identification market, providing in-line printing, coding, and marking products, application specific fluids, and product life cycle services.

Our goal is to partner with our customers in the consumer packaged goods, pharmaceutical, and industrial goods industries to improve their productivity, to protect and grow their brands, and to stay ahead of industry trends and regulations. With our customer application experts and technology leadership in continuous ink jet (CIJ), thermal ink jet (TIJ), laser marking, thermal transfer overprinting (TTO), case coding and labeling, and wide array printing, Videojet has more than 345,000 printers installed worldwide.

Our customers rely on Videojet products to print on over ten billion products daily. Customer sales, application, service, and training support is provided by direct operations with over 4,000 team members in 26 countries worldwide. In addition, Videojet's distribution network includes more than 400 distributors and OEMs, serving 135 countries.



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