Laser Marking Guide for Plant Managers and Other Non-tech Types

LASERAX

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Introduction

Laser marking systems are becoming an increasingly popular direct part marking (DPM) method for full lifecycle traceability in demanding manufacturing and engineering environments. Contrary to traditional DPM methods, such as inkjet marking, dot peening, electro-chemical etching, laser marking offers an array of benefits that simply cannot be matched by other technologies.

While laser marking systems may require a larger initial capital investment, manufacturers in all types of industries attest to the significant ROI they have achieved by adopting this method. For one, laser marking systems are much faster and cleaner than other means. They require no consumables, which is ideal for keeping maintenance, running costs and profit-gouging downtimes to a minimum. Furthermore, laser systems generate high-quality, ultra-precise and permanent marks of all types, such as texts, graphics, linear barcode and 2D codes. Lasers can also mark on virtually all types of materials, making them a very flexible option for any application.

This guide was designed to present an overview of laser marking technology, important considerations to keep in mind when acquiring a laser marking system, and demystify some common preconceived notions regarding operator safety and usability. We hope you enjoy the read!

Laser Direct Part Marking: An Overview

Laser direct part marking is used in many different industries, including aerospace, defense, nuclear, automotive, marine and power-sports sectors, where it is critical to ensure traceability of the parts throughout the product's lifecycle and user safety. Laser direct part marking is also widely used for process control so that manufacturers can identify, in real time, where parts are in the production chain, parts in inventory and if any parts are missing.

Thanks to the very nature of lasers, identifiers can be permanently embedded on even the most difficult surfaces and on almost any type of material, whether it's steel, stainless steel, copper, lead, aluminum, acrylic or plastic. In fact, high-power laser marking has been gaining a lot of traction in the aluminum industry: from sows to billets to cold and hot rolls to extrusions or die castings, information marked by lasers follows parts and products so that all stakeholders downstream of the marking step, can use the data for traceability purposes.

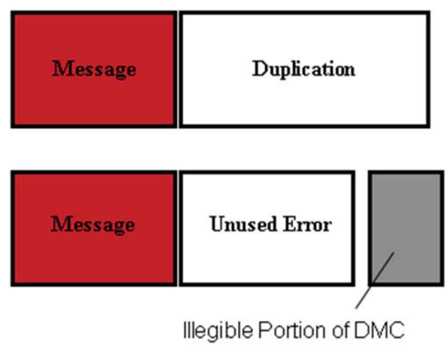
In the long run, what's important to remember is that high-power, near-infrared pulsed lasers are ideal for most marking applications in the primary metal sector. It is interesting to note that laser parameters have to be adjusted for each type of metal. In fact, Laserax has even developed special techniques for laser markings on each type of primary metal, including zinc, lead, magnesium, titanium, nickel, tin, aluminum and stainless steel.

Laser systems etch information directly onto parts and use a non-contact marking approach, which is perfect for marking very hot surfaces, such as metals just getting out of the smelter, hot rolling or forging. What's more, laser systems marks at a very high speed, allowing for marking on parts as they move and enabling very elaborate marks to be added to parts. Manufacturers oftentimes use laser systems for branding purposes, such as adding logos or trademarks to a component, serial numbers, batch numbers and text. Lasers are particularly ideal for encoding mechanisms, like barcodes, Quick Response codes (QR codes) and Data Matrix Codes (DMC), to efficiently convey the most amount of information as possible.

Why You Should Opt for Data Matrix Codes for Direct Part Marking

Laser direct part marking allows manufacturers to embed individual parts or bundles of parts with unique identifiers. However, not all of these identifiers are created equally. And it is important to understand their inherent differences in order to choose the right identifier for your application.

There are three main features that you need to consider when opting for a barcode, QR code and Data Matrix Code: how easily machinery can read the information, how much information the code can contain and its redundancy (or duplication). Duplication means that even if portions of the code are erased, scratched or otherwise rendered illegible, it is still possible to access the information within it.



Let's take a look at the pros and cons of each.

Regular, one-dimensional barcodes are very simple: they feature a single string of information, oftentimes just a few numbers, limiting the amount of data that they can include. Moreover, with no redundancies built in, the minute a barcode is even slightly damaged, the information becomes unreadable.

In order to mitigate the limitations of barcodes risks of having components with indecipherable information, 2D codes are often used. The reason? 2D codes pack a lot more information and afford better redundancies than barcodes. The two most common 2D codes are QR codes and DMCs. Although they look the same, they do have differences.

DMC

QR Code

QR codes of 21 x 21 pixels can hold up to 10 alphanumeric characters, while DMCs of 20 x 20 pixels can hold up to 31 alphanumeric characters, meaning that DMCs have a high storage capacity for the same surface area. DMCs are also more reliable because of their high error correction levels, which allows for much higher redundancy. DMCs are legible even when up to 60% of the code is destroyed—much higher than QR codes' redundancy level of 30%.

DMC ECC 200			QR Code EC Level H		
(legible up to 60% damaged)			*(legible up to 30% damaged)*		
Dimension	Capacity		Dimension	Capacity	
(# of pixels)	Numeric	Alphanumeric	(# of pixels)	Numeric	Alphanumeric
10	6	3	N/A		
14	16	10	N/A		
20	44	31	21	17	10
22	60	43			
41	139	84	40	228	169
80	912	682	81	602	365
120	2100	1573	121	1425	864
144	3116	2335	145	1897	1150
N/A			165	2625	1591
N/A			177	3057	1852

As a result, QR codes are not manufacturers' best bets when it comes to marking parts. DMCs remain legible despite wear and tear, and can contain much more information, which is ideal for industrial applications.

Laser Marking Times: The Parameters That Make a Difference

When planning laser direct part marking on production lines, it's important to factor in different variables that can impact marking time. Over the years, Laserax has conducted lots of different tests using DMCs to determine marking times based on these variables. Let's take a look at them more closely.

Laser marking is a general term that can be used to describe different identification mechanism such as Laser engraving and laser annealing.

Laser engraving melts the metal. It requires large amount of energy over a small period of time

Laser annealing is completely different. The metals change color under the influence of less energy for a longer period of time.

The Material

Marking times are greatly influenced by the type of part material being marked by the laser. Some material requires more energy than others to generate good quality markings. Skip ahead to the section *The Types of Marking* for graphs showing the marking speeds for different non-ferrous metals. The way that more energy is delivered to the material is through a slower line feed and tighter carriage return.

Therefore for a given optical power, reducing the speed at which the laser beam sweeps the surface and tightening the space between consecutive lines increases the density of energy delivered to the material and the time required to engrave an identifier.

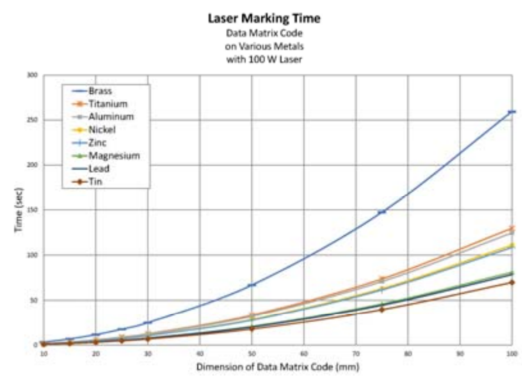
The Marking Mechanism

There are two main marking mechanisms used in laser direct part marking systems: engraving and annealing. Engraving is a type of laser marking that involves high power in a very short amount of time. It creates crevices in the part's material in order to mark it. Annealing is completely different: it uses relatively low power over a longer period of time. The color of the parts surface change due to the interaction between the laser and metal. That's why laser annealing takes more time to mark than laser engraving. Note that aluminum and most non-ferrous metals cannot be annealed.

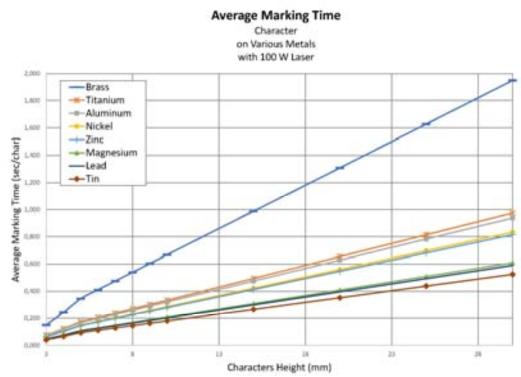
However, annealing is better for applications, such as unique identification (UID) of medical equipment as it reduces the bioburden load. It is also useful for parts that will be subjected to major temperature fluctuations, humidity and salt, such as automotive parts, as annealing prevents the formation of nooks and crannies that may bait in corrosion.

The Types of Marking

When using a laser to mark a part with, the type of marking can also greatly influence marking times. Because DMCs are the most appropriate for industrial applications, we will stick to evaluating the marking times of Data Matrix Code and regular text.



Laser Marking Time as a Function of DMC Size



Average Laser Marking Time as a Function of Text Height

Data Matrix Code (DMC)

For any metals, dark DMC marking on pale background takes the longest. However, this configuration is the most legible under different lighting conditions. In the graph above, you can see the impact of DMCs on the laser marking time for various non-ferrous metals. In the graph above, you will find the laser marking time in seconds as a function of DMC size in millimeters.

Human Readable Text

If a manufacturer needs to mark a string of characters in order to make it readable for humans, the shade (dark or pale) and type of character (filled, outlined or single stroke fonts) also comes into play with regards to marking times. Dark filled characters on any of the metals analysed using a test string and a 100W laser, took the longest to mark. In the graph above, you will find the average marking time per character for text engraved on different metals with dark filled characters.

The Power of the Laser

It stands to reason that more powerful lasers (200 W) can mark information much faster than lasers with lower optical power (30 W). However, high-power lasers are more expensive. In order to determine what type of laser system you should buy, it is important to determine:

1- how your marking time fits within your production cycle time
2- how powerful you need the laser to be based on your specific applications
3- the initial investment you are planning to make to reap the rewards later.

> “ ***There is a tradeoff to be made between the quantity of information conveyed, the power of the laser, the marking time goal and the price of the laser system.***
>
> Paul Rochette, Director of Business Development for Primary Metal at Laserax

How Safe Are Lasers in a Manufacturing Environment?

While laser direct part marking offers a myriad of advantages for manufacturers, it is important to know that high-power lasers, without the appropriate safety measures, can be dangerous to humans over distances as long as 80 metres (263 feet). High-power lasers can cause significant burning and damage within just seconds. Nevertheless, laser marking system can be made 100 % safe. Here is how.

International standards, such as IEC 60825 and ANSI Z136, recommend that Class 4 lasers be embedded in safety enclosures that prevent exposure to the radiation and cannot be opened unless the laser is shut down. Thanks to laser safety enclosures designed to comply with applicable engineering control measures, no other additional protective equipment are required. In fact, a high-power laser in an enclosure is just as safe as an industrial robot in a cage! You can think of the laser safety enclosure just as an elaborate form of machine guarding.

There are two types of enclosures to keep lasers harmless: sealed and open-air enclosures.

Sealed enclosures, as the name suggests, means that the laser is located in a protective housing. The laser will only emit if the enclosure is completely closed, thereby preventing access to the area where the laser beam intensity may be hazardous.

Sealed Enclosures

Open-air enclosures also house a high-power lasers and are used mainly when parts are too big to fit into sealed enclosures. Contrary to sealed enclosures, one of the sides of the enclosure is open so that the part to be marked can come into contact with the laser enclosure. The laser will only emit when it is safe because the part is present and the seal is adequate. Properly designed open-air enclosures include several engineering control measures. Other user control measure may be required to comply with applicable safety standards.

Open-air Enclosure

Finally, high-power lasers can be operated **without enclosures**, but there is one major caveat. Using lasers without enclosures means that critical control measures, including comprehensive safety procedures, laser-controlled area, warning signs, signals and lights, continuous staff training, protective apparel, gloves and eyewear must be instilled and enforced.

Laserax's Modular Approach to Laser Systems

Contrary to custom engineering, which can be costly, lengthy and complicated to implement, Laserax has developed a unique modular approach to its laser systems so that you can select and combine the right lasers, options, safety enclosures that meet your laser marking and laser cleaning needs. It is the best way to take advantage of maximum flexibility without breaking the bank!

Examples of Laserax Laser System

Automated Laser Marking System on a Conveyor

This client, which operates in the primary metal industry, uses Laserax's laser marker on a conveyor. Equipped with guillotine doors on both sides and sophisticated sensors, the sealed enclosure detects when a bundle of lead ingots is ready to be marked and then passed onto the next production step.

Automated Laser Marking System with Rotary Table

Another client, in the motor-sport industry, installed our laser marking system with inline enclosure, with an integrated rotary table, for automatic feeds from the robot servicing its die-casting machine. The laser marking occurs as the robot does other value-added tasks.

Mobile Laser Cleaning System

Laserax's mobile laser cleaning system has been designed to clean weld, remove paint, rust and other contaminants from metallic parts. The system is particularly beneficial as it requires no consumables and little to no maintenance over its entire useful life.

Acknowledgement

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Most photos used in this guide have a CC0 License and were sourced on Pixabay.com such as the ones on pages 9 and 11 . The photo on page 1 comes from UC Rusal Photo gallery on Flickr. The photo of the steel coils on page 3 comes from the Worldsteel photo gallery. The image of a steel furnace on this page came from twenty20.com

About

Laserax is a laser system manufacturer that provides efficient, innovative and safe solutions for the most demanding industrial applications. We rely on a team of laser technology experts to offer a complete range of products for laser marking and laser cleaning.

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