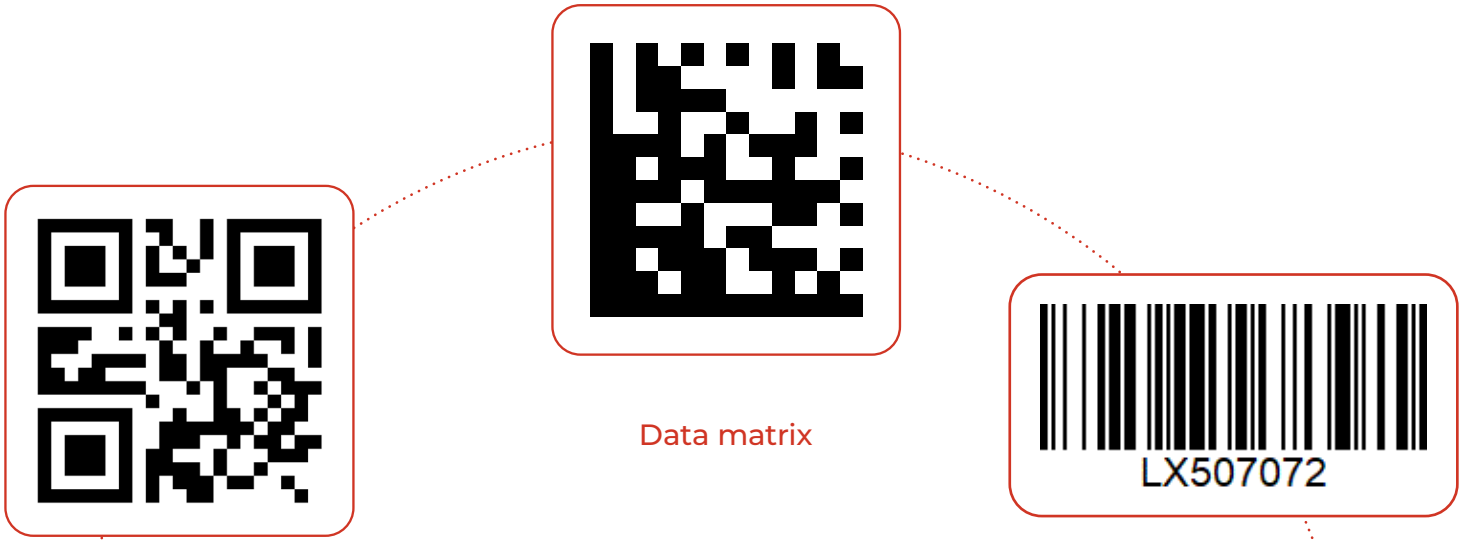
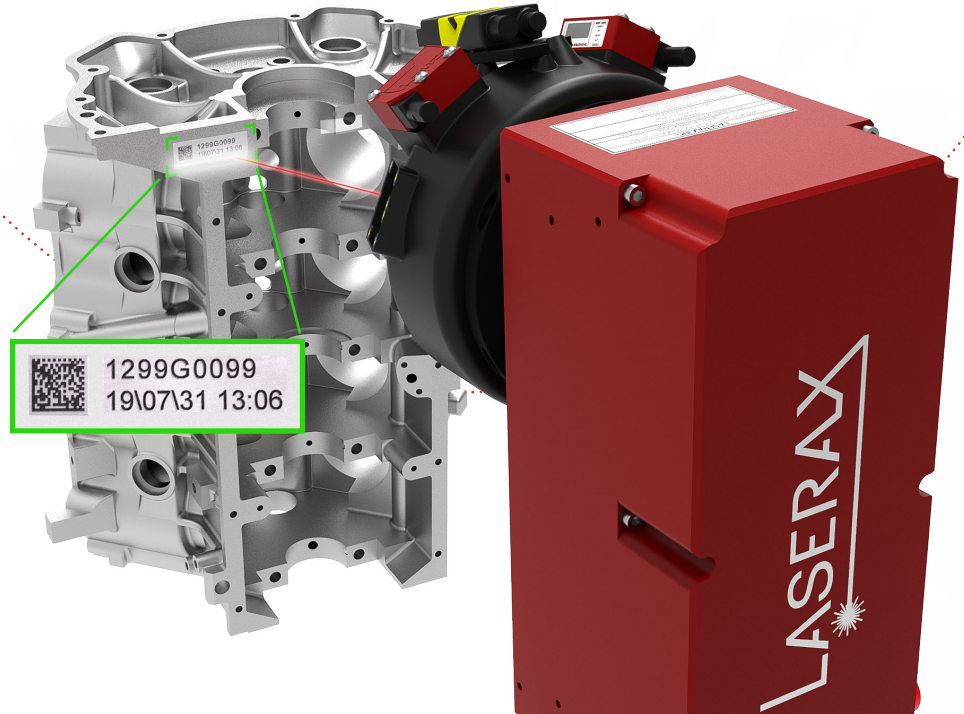
LASERAX

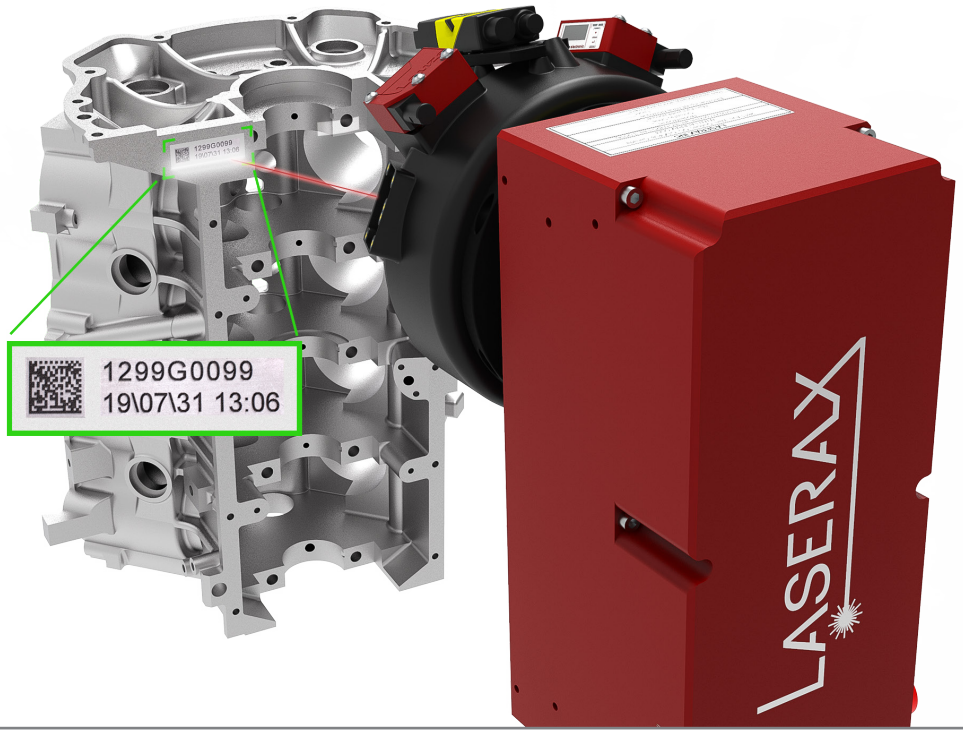


HOW BARCODES WORK

A Guide on Industrial Traceability



HOW BARCODES WORK



If you are producing high-value or safety-critical parts, traceability is essential to protect your business from serious consequences related to product recalls and counterfeiting. High-quality barcodes are at the heart of a good traceability system.

We've created this guide to help you understand how to use barcodes for traceability. You will also find related tips for production lines.

Topics covered in this guide:

THE TYPES OF BARCODES

A “barcode” is a general term that refers to black-and-white symbols used to encode information. Barcodes cannot be read by humans; they can only be read by barcode readers.

They contain information such as:

- **Source manufacturer**
- **Manufacturing or assembly facility**
- **Place of origin**
- **Production time and date**
- **Lot number**
- **Part number**
- **Model number**
- **Serial number**
- **Components used in assembly**
- **And more...**

ALPHANUMERIC CHARACTERS

Alphanumeric characters are, in simpler terms, letters and numbers. While they’re not barcodes, they’re often used alongside them to provide partial traceability information simply by looking at them—without the need for a barcode reader.

Marking your company name directly onto parts, for example, can be useful to quickly identify which parts you produced when dealing with customers who have several suppliers.

Serial numbers and **batch numbers** are also frequently marked directly onto parts. They can be read by humans in case the code is too damaged and has become unreadable.

DID YOU KNOW?

Serial numbers provide improved traceability compared to batch numbers

In die-cast cells, a batch number used to be formed in the die so that all castings produced with the same die were identified with the same series of alphanumeric characters. This provided what is called batch traceability.

Nowadays, laser marking is used to identify every single part with a unique serial number—and batch numbers are no longer used. Identifying every single part with a unique number has allowed die casters to increase their traceability capabilities and better manage recalls.

1D CODES (LINEAR BARCODES)

Linear barcodes, also known as 1D codes, are sequences of vertical black bars and white spaces. They are typically marked with their corresponding alphanumeric characters. When it comes to traceability, the most common types of 1D codes are Code 128 and Code 39. There are many other types of 1D codes, but they are used for other applications.

Example of Code 128

2D CODES: QR CODES VS DATA MATRIX CODES

2D codes provide great advantages when it comes to traceability. Their structure allows them to suffer damage and still be readable—which helps make the entire traceability process more reliable. 2D codes also provide a better density of information and hence increase the quantity of information that can be stored on products while minimizing space usage.

The most common types of 2D codes used for industrial traceability are QR codes and Data Matrix codes. These codes are made of alternating black and white modules.

Quick Response Codes (QR Codes)

QR codes are easy to recognize from the three square patterns in their corners. They also have alternating black and white pixels that follow a line between each square to indicate the spatial frequency of columns and rows in the code.

Data Matrix Codes (DMCs)

Data matrix codes have black lines following two of their edges. These lines are used by barcode readers as localization features. Alternating black and white pixels follow the two other edges to indicate the number of columns and rows in the code.

DID YOU KNOW?

Data matrix codes are better than QR codes for industrial traceability

Given the same surface area, data matrix codes can store more information than QR codes. This is because the localization mechanism of QR codes occupies a larger portion of the code. Since DMCs can be of smaller size, they can be marked faster. This means that marking barcodes can be integrated more efficiently in production lines—without slowing them down.

HOW BARCODES WORK

It's important to understand six key features to optimize how you use barcodes. Let's look at them.

CODE SIZE

Code size and physical size are not the same thing. A 20x20 DMC, for example, has 20 rows and 20 columns. Its actual physical size is not necessarily 20x20mm.

The amount of information that can be stored in a code is limited by its size. The more information you store in a code, the bigger it will need to be.

In 2D codes, the number of rows and columns increases with the amount of encoded information. In 1D codes, the number of vertical bars increases.

If you want to know the storage capacity for specific code sizes, refer to Storage Capacity for Data Matrix Codes at the end of this document.

Same physical size, different code size

PHYSICAL SIZE

The physical size of a code refers to its length and width in millimeters. It is important because barcode readers may have a hard time reading codes that are too small.

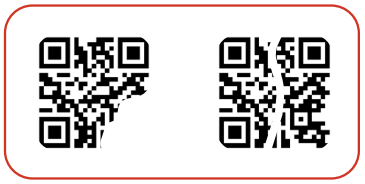
- The size of each pixel in 2D codes (or the width of each bar in 1D codes) must be compatible with the barcode reader's resolution.
- Size must also be compatible with the marking method, meaning that the marking system must be able to create markings of the specified size with enough precision. Mechanical methods like dot peen systems are limited by the size of the stylus and cannot reach the same level of precision as laser systems.

Same code size, different physical size

ERROR CORRECTION

One of the advantages of 2D codes over 1D codes is that they offer error correction. This means that 2D codes can suffer significant damage and still be readable. Error correction is made possible by including redundant pixels in codes. It ensures greater reliability.

- Data matrix codes can be read even when up to 30% of the code's surface is unreadable. The capacity for error correction is automatically determined by the free space available in the code for redundant information.
- QR codes use a parameter known as ECL (error correction level) to determine the amount of damage codes can withstand: Low (7%), Medium (15%), Quartile (25%), and High (30%).



Example of damaged codes

CONTRAST

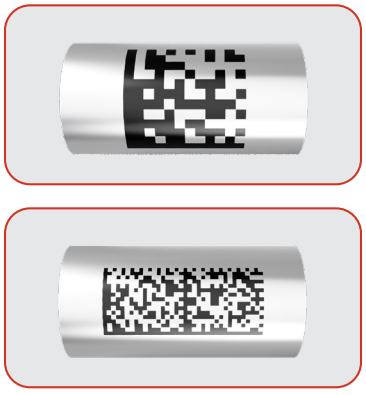
Barcode reader technology is based on the idea that black lines reflect less incident light than white lines. To read a code, barcode readers direct a light source at the code, then a photodetector measures the quantity of light that is reflected.

As such, the readability of codes is affected by the level of contrast between black and white pixels. Contrast can be affected by several factors, such as the color of the base material being marked, or the marking technology.

SHAPE

While QR codes can only have a square shape, Data Matrix codes can have a square or rectangular shape. The code's shape is not an issue on flat surfaces, but it's an important consideration on curved ones.

When codes are placed along curved surfaces (such as on cylindrical objects), barcode readers view them as if they were wrapped, making them harder to read. The effect of code wrapping can be limited by using rectangular instead of square codes. This allows placing most of the code along the portion that is not aligned with the curvature



Example of code wrapping

QUIET ZONE

The quiet zone is a no-print area that prevents surrounding noise from being misinterpreted as actual information. This zone improves the code's retrieval during reading.

- In 1D codes, the quiet zone is a blank margin on both sides of the barcode.
- In 2D codes, the quiet zone is a surrounding white margin all around the code.

Quiet zone

DID YOU KNOW?

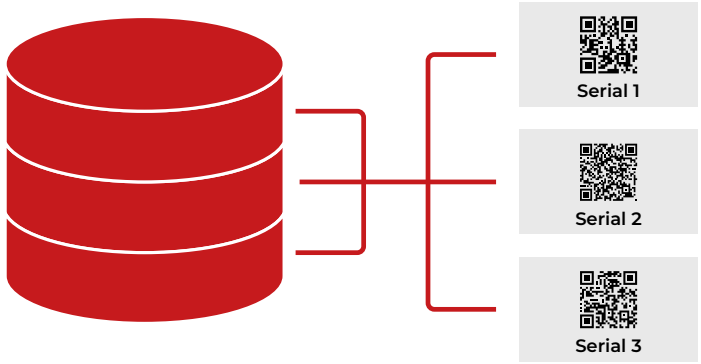
Laser systems create higher-contrast codes than dot peen systems

Manufacturers who use dot peen systems to mark barcodes directly onto parts often encounter contrast problems. This is because dot peen systems leave small holes that permanently change the part's roughness and visual aspect, but they offer little control over the surface color.

As a result, barcode readers often need special lighting conditions to read data matrix codes made by dot peening. This is not the case with codes that are laser marked. Laser marking systems can easily create different shades of black, white, and gray.

THE IMPORTANCE OF DATABASES

Instead of putting your traceability information in codes, you can put serial numbers in them. Serial numbers can then refer to unique IDs in your database. This strategy offers several advantages.



CONTROL OVER THE INFORMATION

Nowadays, anyone can download a barcode reader on their phone and scan the information you put in your codes. If you want to restrict public access to your manufacturing information, you need to store your traceability information in a database. This way, people only see a serial number when they scan your codes.

SMALLER CODES

If you put less information in your codes, they will be smaller. Smaller codes can be marked faster, which means that the marking operation will be more efficient. Smaller codes also use up less space on your parts, which helps deal with space constraints you may have.

MORE INFORMATION

Manufacturers often want to put as much information as possible in their codes, but codes can only store limited information. Databases have no limits. They can add as much context as you want to the information extracted from barcodes.

DID YOU KNOW?

If you don't want to use a database, it's good practice to limit the amount of information you store in codes

When all your traceability information is stored directly in the code, the code is larger and requires longer marking times. You should choose sparingly the traceability information to limit the marking operation's impact on your production line.

INDUSTRIAL LASER EXPERTISE THAT MAKES THE DIFFERENCE

When you contact us, we go over your production process with you to understand how you manufacture your parts. After careful analysis, we propose a complete solution that considers all factors for a successful laser integration. From your first inquiry to the commissioning and after sales support, our commitment is to make ourselves available to assist you at any moment.

CONTACT US

If you have a project and need a laser, we are here to help you.

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