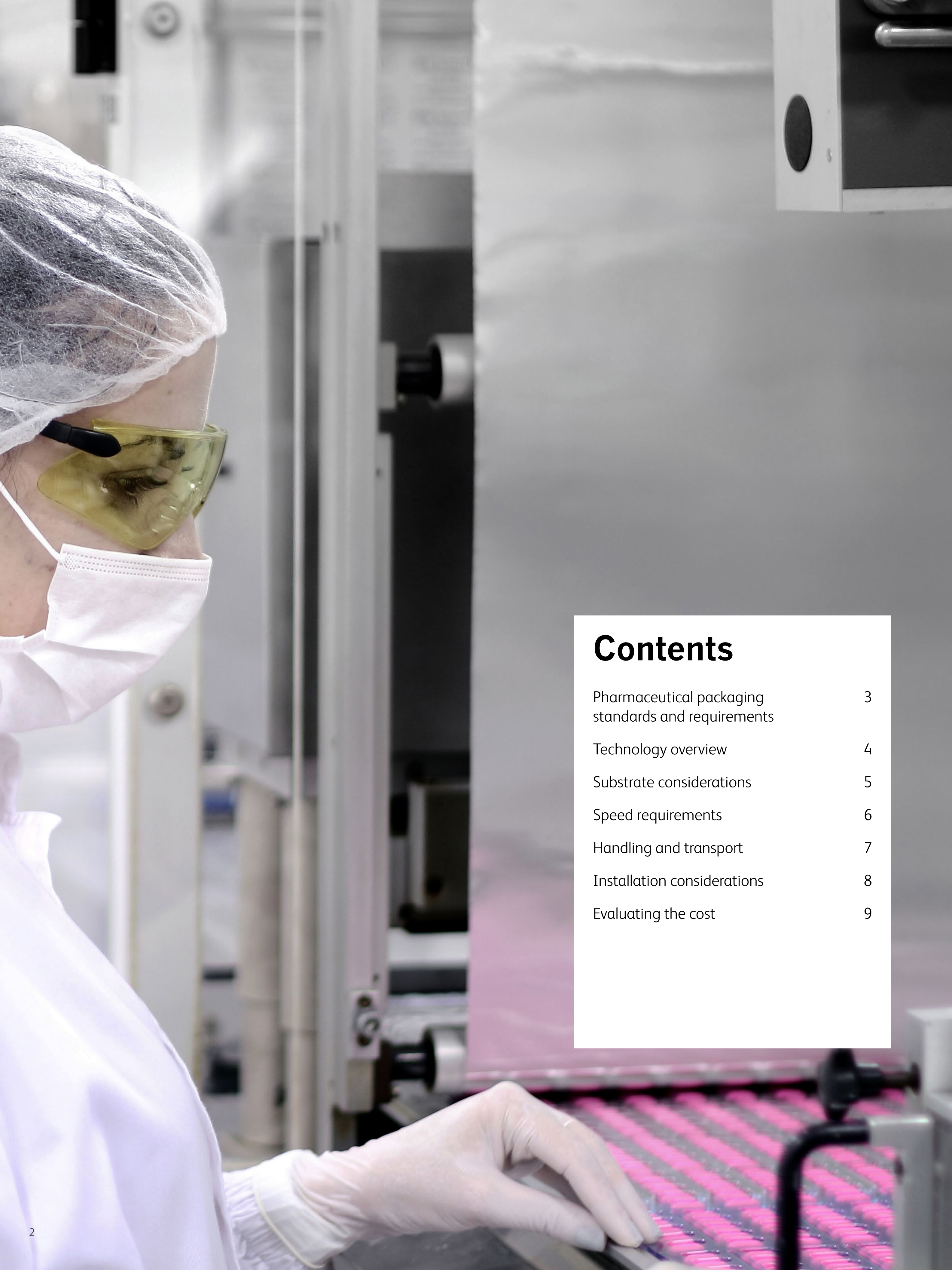
White paper

Pharmaceutical packaging serialization

Evaluating coder technologies to print high-quality alphanumeric and DataMatrix codes

The DataMatrix code has become the standard code carrier for a number of regional and country-specific serialization initiatives. Both laser and thermal inkjet (TIJ) printing provide high-resolution codes suitable for the detail required for DataMatrix symbols and multi-line printing.

This white paper provides an overview of DataMatrix printing with both laser and TIJ technologies.



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Pharmaceutical, life sciences and healthcare packaging operations are held to demanding standards that vary across the globe

Packaging standards are growing in complexity as manufacturers serve an increasingly global customer base, and serialization requirements continue to be deployed across a number of countries.

Life sciences packaging needs have driven innovation in the coding and marking industry in the recent past and will continue to do so for the foreseeable future. Over the last decade, manufacturing needs for high resolution printing, serialization and printer cleanliness have fueled continued development of existing printing equipment and the introduction of new print technologies. As a result, packaging engineers and managers now have several printing technologies to choose from to meet their needs.

Improperly executed, coder selection can be a source of frustration that can impede the speed and productivity of packaging operations. Properly specified and selected, a coder is an important element for packaging line operations. With increasing frequency, packaging leaders are being asked to specify between the two most common print technologies for serialized marking: laser and TIJ. The DataMatrix code has become the standard code carrier for a number of regional and country-specific serialization initiatives. That said, the comments and recommendations contained within this document are applicable for a range of applications requiring high quality coding and marking, including DataMatrix codes.

High-quality alphanumeric and DataMatrix codes

Technology overview

Both laser and TIJ printing provide high-resolution codes suitable for the detail required for DataMatrix symbols and multi-line printing. TIJ printers fire tiny ink drops onto packaging as it passes by the cartridge, or printhead. These ink drops are propelled out of a row (or rows) of fine-gauge nozzles by the rapid cycling of a small resistor underneath each nozzle. These resistors boil a small amount of ink which creates a small steam bubble that propels the ink drop (Figure 1).

In contrast, laser coders use a focused beam of light to inscribe or physically alter the top layer of a substrate. The beam of light is steered by two mirror galvanometers which direct the laser beam in two planes (Figure 2).

To identify the right technology for a given application, the following criteria must be considered:

- **Substrate**
- **Speed**
- **Substrate handling and transport**
- **Installation considerations**
- **Cost (capital and operating)**

Figure 1

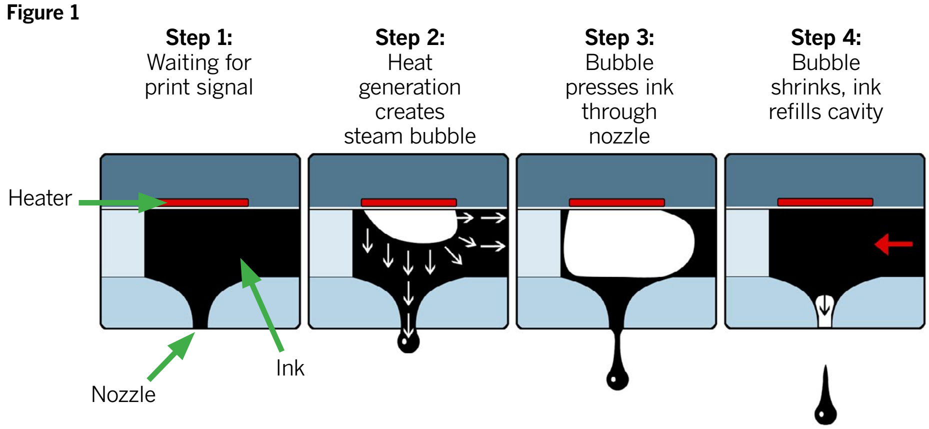
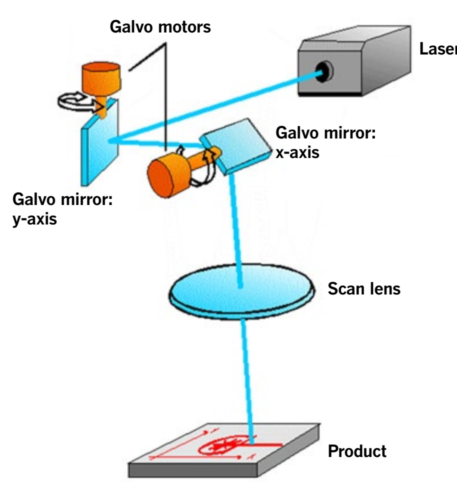


Figure 2



Substrate considerations

The material being marked, the substrate, should be the first criterion in coding technology selection. Of the two technologies, TIJ is more limited in substrate application and this factor can often simplify the choice for the packaging engineer. That said, both technologies require some evaluation for substrate selection and preparation.

Pharmaceutical cartons and paper label stocks typically have an aqueous overcoat to protect the packaging material. Until recently, TIJ inks were traditionally water-based, and therefore would not adhere effectively to substrates with an aqueous overcoat. Using TIJ technology in the past meant asking packaging suppliers to modify the last step in the printing process to avoid placing the aqueous overcoat over the print window (this step is referred to as adding a "knock-out" to the packaging). Innovation in TIJ technology, however, has introduced inks formulas that include methyl ethyl ketone (MEK) or other light-solvents, broadening the spectrum of applications TIJ can address. Substrates such as foils, films, plastics and coated paper stocks are all now addressable with a TIJ technology that utilizes MEK-based inks. Identifying the correct TIJ solution now becomes a consideration of required dry times. A water-based ink on a porous substrate still offers the best dry time, followed by MEK-based inks, and finally light-solvent inks. A coding and marking specialist can help you consider the benefits of each alternative, and identify the correct solution for your application.

Laser marking addresses an even wider substrate range, with the ability to mark on paper, plastics, metal and glass. Additionally, lasers are capable of coding on curved surfaces such as vials or bottles. The most common pharmaceutical applications require marking on paper (cartons and labels) as well as some plastics and metal foils (label materials, sealing and barrier materials). In these applications, the laser mark is formed most commonly via ablation (CO_2 and fiber lasers physically burn the top layer of material). There are two considerations when it comes to verifying suitability of the substrate with laser technology: absorption of laser light and creating a print window with sufficient contrast for high quality bar codes. Absorption is a function of the substrate and the selected wavelength of the laser. This criterion should be verified by the coding and marking supplier. For proper code contrast, it is commonly required to modify packaging with a print window of dark ink, referred to as a "flood fill." The laser burns off the top layer of dark ink to expose the lighter underlying substrate – making a negative image. Lasers can slightly yellow the underlying substrate, and this can result in lower bar code contrast (Figure 3).

Figure 3

Bar Code Grade Parameter	Code Examples
Symbol Contrast	

For optimum results, packaging can be specified to include a layer of white ink with titanium dioxide or calcium carbonate to be applied before the flood fill is applied. This boosts the reflectance of the white part of the code, and can improve bar code contrast and readability.

Packaging line speed

Key decision criteria for maximum efficiency

Speed requirements

Packaging engineers need to ensure valuable assets like packaging machinery and skilled operators are being utilized as efficiently as possible. Therefore, line speed and throughput are key decision criteria for manufacturers. For TIJ, maximum line speed is a simple calculation governed by the selected print resolution of the code (in the direction of substrate travel) and the maximum speed at which the resistors can be turned on and off (the firing frequency). The complexity of the code (e.g. two lines of text vs. four lines of text) does not impact maximum line speed since TIJ technology can fire all nozzles simultaneously – one of its key advantages. Therefore, a four line code with a DataMatrix bar code can be printed at the same line speed as a simpler two line lot and expiration code. This aspect of TIJ technology is a helpful reassurance for packaging engineers who anticipate adding code content in the future for internal traceability or external (e.g. regulatory) requirements.

Calculating maximum laser line speeds, on the other hand, is a bit more complex than TIJ since multiple factors influence maximum line speeds. These factors include:

- Substrate – how much energy (time) is needed to ablate the material to form the code?
- Lens size and marking field size – how much time does the laser have to “engage” the product for marking?
- Code size and complexity – how much code content is required and how much total time is required to form the code?
- Product pitch – how closely spaced are the products? And how does this impact the amount of time the laser can engage the lead product before transitioning to the product immediately following?

For the majority of the common pharmaceutical applications described here, a typical 30-watt CO_2 laser or 20- or 50-watt fiber laser offer very competitive line speeds compared to TIJ technology. As the substrate becomes more challenging (e.g. plastics, foils, metals), this may require longer mark times and slower running lines. A coding and marking specialist should assist with an application assessment given the multiple factors detailed above.

Throw Distance

Substrate handling and transport

Both lasers and TIJ printers require smooth, vibration-free transport of the substrate in order to provide the highest quality codes. Lasers must be properly integrated into the line with robust mounting hardware to ensure there is no vibration during operation. The plane of the marking lens must also be held perfectly parallel to the substrate being marked with one axis of the marking head at 90 degrees to the direction of substrate travel.

Both technologies can operate in continuous and intermittent (stop and go) packaging applications (Figure 4). An advantage of laser is its ability to print on either moving or stationary packaging. By comparison, a TIJ printhead requires the substrate to traverse across the front of the printhead in order to apply a code. Alternatively, a TIJ printhead can be physically traversed across a stationary substrate, but this adds some mechanical integration to the packaging line.

Figure 4

Continuous	Intermittent
Carton coding	Bottle labeler
Web-based printing	Medical pouches and blister packs

The maximum allowable distance between the coder and the substrate to be printed varies between a TIJ printer and a laser. By design, TIJ printheads must be placed very close to the substrate. Typically, this distance, referred to as "throw distance," should not exceed 2 mm for high quality DataMatrix codes. Variation in excess of 2 mm can result in fuzzy characters and unreadable DataMatrix codes (Figure 5).

Figure 5

1 mm throw distance

- Crisp modules
- Excellent edge acuity

4 mm throw distance

- "Fuzzy" ill-defined modules
- Drop placement accuracy degrades

Lasers offer some advantages relative to TIJ – both in terms of the distance between the focal lens and the substrate and the allowable variation in product placement. A typical carton coding application may require a 100 mm focal distance with an allowable tolerance of +/- 3 mm for the position of the package relative to its nominal marking position. This incremental tolerance provides some margin of safety with respect to material handling.

Installation considerations

Factors for a successful integration

Installation considerations - TIJ

Despite the throw distance limitation of TIJ, the technology is inherently clean and the printheads are relatively small, aiding integration into packaging lines. Sub-second dry times are achievable with leading inks and guide rails should be appropriately positioned to avoid contact with the printed code immediately downstream of the printer.

Installation considerations - Laser

Laser marking technology requires two additional considerations for proper and safe installation: beam enclosures and fume extraction.

For operator safety, enclosures need to be installed that prevent access to the laser energy during normal operation. These enclosures should include interlocks for access doors and warning labels on all removable panels. If material handling considerations prevent the full enclosure of the laser system, beam shields should be employed directly surrounding the marking head. For CO_2 lasers, polycarbonate and acrylic are acceptable beam shield materials. For fiber and Nd-YAG lasers, enclosures should be constructed of sheet metal. Additional details can be found in ANSI standard Z136.1.

The ablation process for laser marking creates fumes that contain small particulates and gases that may be a health hazard. The lasering of chipboard cartons and paper labels will also result in particulates that could be inhaled by line operators. Best practice for any laser installation includes the deployment of fume extraction with a filtration system. Typically three levels of filtration are employed: a pre-filter for coarse particulates, a HEPA filter for fine particulates, and a chemical filter to trap gases and eliminate odors. A coding and marking specialist can provide guidance on the above mentioned elements of a laser installation.

Capital and operating costs

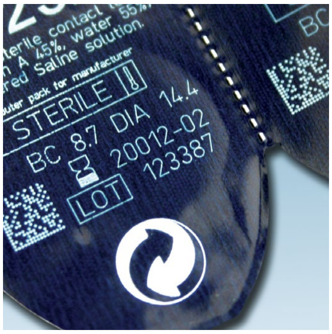
A coding and marking specialist can provide a customized cost comparison of suitable printing technologies, taking into consideration the unique requirements of a given application.

Evaluating the cost

Investment and operating costs are key considerations, and laser and TIJ offer two different capital acquisition models. On total cost of ownership, TIJ and laser can be competitive solutions, however TIJ has a lower capital cost than laser technology. This advantage is magnified whenever multiple print locations are required on a given substrate. TIJ coders have the opportunity to add several printheads to a given controller – providing an easy way to print on two (or more) sides of a given carton or printing on multiple lanes. Lasers benefit from eliminating the need for inks, but operating budgets should take periodic filter replacement into consideration. The frequency of replacement will be governed by the amount of filter loading based upon the amount of debris and fumes for the given substrate. Throughput and utilization of the packaging line are also factors to be considered. A coding and marking specialist can provide a customized cost comparison of these two technologies, taking into consideration the unique requirements of a given application.

Conclusion

There are a number of factors that should be evaluated when selecting between laser and TIJ coding technologies. There is no criterion which single-handedly tips the decision in one direction or the other. A coding and marking specialist with knowledge of both technologies can evaluate the specific needs for a given application, assess anticipated needs for the future, and make application-optimal recommendations. With this advice, companies can then apply their own rankings to this set of consideration criteria to make informed decisions about the marking technology that best meets the needs of their packaging operation.

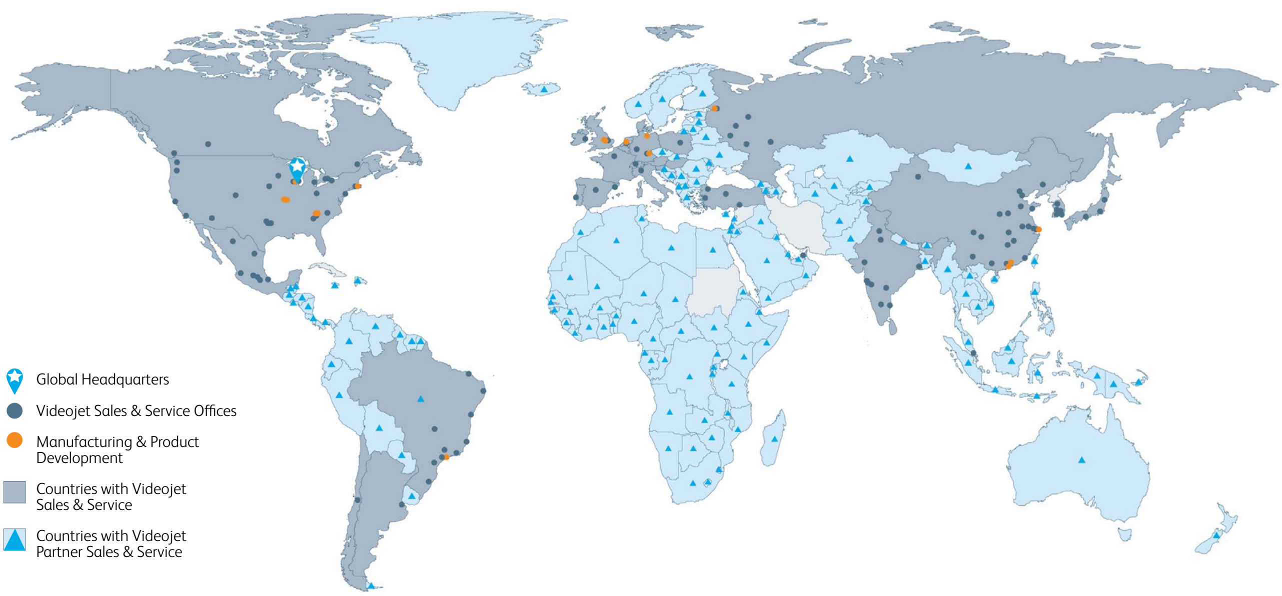


Peace of mind comes as standard

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 Inkjet (CIJ), Thermal Inkjet (TIJ), Laser Marking, Thermal Transfer Overprinting (TTO), case coding and labeling, and wide array printing, Videojet has more than 325,000 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 3,000 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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