

White Paper: Which Printing Technology Is Best for Variable Data 2D Codes on Retail Packaging?

A practical guide for operations, quality, and brand teams



Introduction

Many retail and supply chain stakeholders are considering how to adapt their packaging to include in line printing of 2D barcodes. This shift is being driven by several initiatives, including GS1's Sunrise 2027 programme for retail point-of-sale scanning, digital deposit return schemes (DDRS), consumer engagement programmes, and taxation initiatives.

There are many benefits of introducing 2D codes such as QR or Data Matrix onto packaging but there are several factors to consider to achieve the best results while maintaining maximum operational efficiency.

One of the areas that creates confusion is which type of printing technology is best suited for printing 2D codes. The answer depends on multiple variables, including the amount of data and data elements to include, potential serialisation for batch of one, substrate choice, product handling consistency and line speed amongst others. This guide will help you reach an informed decision.



Start with the Data

This is a complex topic, but first you must decide why you're using 2D codes and which stakeholders need to access the data. This will then guide you on what information you need to include in your code. The goal is to deliver a high-quality print that scans reliably, and remains durable throughout the supply chain, without compromising line speed, or the design of your packaging.



Product Handling & Verification

Whichever technology you choose, consistent product handling at the point of coding is critical to ensure the highest scan rates and minimise on site rejects or more costly returns.

What may look acceptable to the human eye, now also needs to be read by multiple scanning systems through from production to consumer purchase.

Adding an inline verification system is equally important to detect issues in real time, not after products enter the supply chain, where recalls can be very expensive.

Choose the Right Partner

Selecting the right supplier to help you on the journey is essential. You need a partner with extensive experience in applying 2D codes with variable data to packaging, with a comprehensive range of printing and verification technologies and the expertise and experience of applying 2D codes to packaging to match the right solution to your application. This allows you to select the best technology for your applications from a number of possible suitable options. There is no 'one size fits all' approach, it may be that your site needs a range of technologies based on the packaging types and applications within your production.

Printing Guides

When deciding which technology to use, careful consideration needs to be given to the exact requirements including substrate, line speed and data requirements.

The amount of data you choose to include in the 2D code will affect the overall size to ensure readability once scanned. However, with usual point of sale (POS) data elements resulting in a QR code around 18-20mm square, this will also then mean a quiet zone is needed of around 2mm. To allow enough space for the 2D code a printing area of greater than 25mm is needed.

1. Thermal Transfer (TTO)

Thermal transfer overprinting (TTO) is an ideal solution for flexible packaging applications, delivering high-resolution, variable data codes. With the ability to run at high speeds, thermal transfer overprinters are often incorporated into form-fill-seal machines, for efficient coding without slowing down production.

By transferring ink from a ribbon onto the substrate, TTO ensures consistent and reliable prints that last throughout the supply chain. It can operate at high speeds without compromising quality and is frequently used in food packaging.

2. Thermal Inkjet (TIJ)

Thermal inkjet (TIJ) delivers crisp, high-resolution codes that meet the demands of modern traceability and brand presentation. TIJ excels at producing sharp, scannable 2D codes with greater data capacity, ensuring reliable performance throughout the supply chain. With little down time, and a low maintenance operation, it has become the preferred choice for manufacturers seeking quality and efficiency.

TIJ is ideal for applications where code clarity and consistency are critical, such as retail packaging, pharmaceuticals, and premium consumer goods.



3. Laser Marking

Laser Marking offers permanent, high-quality marking that stands up to the most demanding production environments. By etching directly onto the substrate, laser technology reduces the need for consumables, lowering long-term operating costs and minimising environmental impact. There are 3 types of laser typically used in coding and marking applications, CO2, fibre and UV, all providing different benefits and safety considerations, and requires very strict safety measures. Laser delivers precise, durable 2D codes that maintain integrity throughout the supply chain, even under harsh conditions. Laser marking is ideal for applications where permanence and premium presentation are essential.

However, it may not always be suitable for 2D codes containing large amounts of data on lines that need to run at high speeds. Additionally, depending on the material the codes may lack the contrast required for efficient retail scanning. It is best practice to complete sampling for a specific packaging application before adopting laser for 2D Codes.



	CO2 Laser	Fibre Laser	UV Laser
Paper / Paper Laminate	✓		
Carton	✓		
PET	✓		
Glass	✓		
Flexible Film (recyclable)			✓
HDPE / LDPE white			✓
HDPE / LDPE dark		✓	✓
PP light coloured			✓
PP dark coloured		✓	✓
Aluminium		✓	
Steel		✓	

4. Piezo Inkjet (PIJ)

PIJ technology combines precision and flexibility to deliver high-quality, high-resolution codes across a wide range of substrates. Using piezoelectric printheads, PIJ enables accurate drop placement for crisp, scannable 2D codes with excellent data density. It supports fast line speeds and variable data printing without compromising quality, making it ideal for applications that demand both performance and adaptability. With minimal maintenance requirements and compatibility with diverse ink types, PIJ is a robust solution for manufacturers seeking reliability and superior print results. Complete PIJ systems usually have a higher initial cost than other technologies but for brands that want 2D codes to match the premium quality of the rest of the packaging print, it is an ideal choice.



5. Continuous Inkjet (CIJ)

Continuous inkjet (CIJ) is a capable solution for printing 2D codes, particularly data matrix, in many environments including industrial, pharmaceutical and construction. Due to its large installed base, it is often the technology discussed initially, particularly by manufacturers who only have this technology to offer. However, for retail packaging the requirements are far more stringent. Brand owners want the 2D code to be of comparable quality to the rest of the packaging and at point of sale the code must be read in a very short window of time. If this is not achieved, the checkout operator may reject the product.

Retailers are generally demanding the code includes variable data such as batch information and best before dates. This specification makes the 2D Codes data rich but also large in size, ruling out CIJ Technology in the majority of cases.



Summary

This white paper provides a practical guide for operations, quality, and brand teams to make informed decisions.



Conclusion

The successful adoption of 2D codes on retail packaging requires more than simply selecting a printer. To achieve reliable performance throughout the supply chain, manufacturers should consider:

Data requirements – the amount and type of information to be encoded, including any serialisation needs.

Substrate characteristics – the material, surface finish, and packaging format being marked.

Available print area – ensuring sufficient space for the code and the required quiet zone.

Production line speed – matching the coding technology to throughput requirements.

Product handling – maintaining consistent product presentation at the point of coding.

Verification processes – implementing in line code inspection to ensure quality and readability.

Technology Summary

Continuous inkjet (CIJ) – a proven and widely installed technology that can print 2D codes, but may be challenged by larger, data-rich codes requiring high scan reliability at retail POS.

Thermal transfer overprinting (TTO) – ideal for flexible packaging applications, delivering highly durable, high-resolution codes, although ribbon usage can increase consumables costs and waste.

Thermal inkjet (TIJ) – provides excellent print quality, high scanability, low maintenance requirements, and is well suited to retail packaging applications.

Laser marking – offers permanent, high-quality marks with low ongoing consumable requirements, although substrate suitability, contrast, and safety considerations must be assessed.

Piezo inkjet (PIJ) – delivers premium print quality, and strong performance at higher line speeds.

There is no single technology that is best for every application. The most effective solution is one that balances code quality, scanability, operational efficiency, sustainability objectives, and total cost of ownership.

By working with an experienced partner that offers multiple coding technologies and application expertise, manufacturers can confidently select the right solution to support the transition to QR codes in retail and for future traceability, regulatory, and consumer engagement initiatives.



TALK TO AN EXPERT

Telephone: +44 1954 782 056

www.domino-printing.com