TSC PRINTRONIX AUTO ID

What is Barcode Inspection?

An overview of the technology, the options, and considerations for label and barcode inspection

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Introduction

A label is a representation of your company and product. It is likely the first thing the customer sees and evokes an immediate impression of the sender. Even with the best intentions and industrial design, it is possible for a speck of dust caught under the print head, a print head element failure, or a wrinkle in the ribbon to render a barcode on your label unreadable.

This unreadable barcode impacts automated processes downstream, generating additional work for your customer, and potentially resulting in chargebacks or returned shipments. If you have added a QR code to a package with a link to a video for installation instructions, or a QR code with a link to facilitate product registration, an unreadable QR code represents a missed opportunity to enhance customer satisfaction with your product. There is absolutely nothing good gained from an unreadable barcode.

In this eBook, we will provide an overview of the technology, the options, and considerations for label and barcode inspection to avoid the impacts and costs of a barcode that doesn't meet your customer's standards for quality.

What is Barcode Inspection?

Barcodes are made up of a defined pattern of lines or shapes that represent a means of transmitting information. Barcodes use a simple on-off scheme to represent characters, numbers, and symbols. If you envision a very tiny magnifying lens that you move across the barcode in precise steps, you could record the image in the lens at each step as "dark" or "light". If we use a "1" for "dark", and a "0" for "light", you could imagine the results as something like 0001100011000110001111 and so forth. Dots on a piece of paper have become a string of 1's and 0's that computers are particularly adept at interpreting rapidly.

There are defined symbologies for barcodes, which is simply a way of saying that folks got together and agreed on a pattern of these 1's and 0's as representations of numbers and letters. Add some rules for what defines the boundaries of a barcode pattern and you have an easy way to transfer information in a computer readable format using only paper and ink. Simple, inexpensive, quick, and available to impact, laser, inkjet, thermal, or other printer technologies.

The success of this encoding scheme, first launched in 1974, has led to universal and ubiquitous adoption of barcoding technology. Adoption was so successful that demand for even greater storage capacity in the barcode grew. A linear barcode can only grow in one dimension and it was clear that the physical label size was going to constrain the capacity. So, a new breed of barcodes were developed to add a second dimension for growth, creating what is known as 2D barcodes. The 2D symbologies can have both an x and y dimension, enabling more data to be packed into the barcode. Today up to 7,000 characters are possible to transfer in a 2D barcode.

What Can Possibly Go Wrong With a Simple Barcode?

The success of this encoding scheme, first launched in 1974, has led to universal and ubiquitous adoption of barcoding technology.

With such a wonderfully simple architecture, what could possibly go wrong to render a barcode unreadable? Barcodes rely on the point being inspected as being either "light" or "dark." What if the ribbon has a flaw or a wrinkle, the inkjet nozzle doesn't fire correctly, or the print density was set incorrectly and a poor quality dot is laid down? Is the dot light? Is it dark? Or possibly indeterminate?

If the paper stock has background color that reduces the contrast, if there is a smudge or streak in the paper, or if the printer puts down a light dot, there is a chance that the inspection cannot make a clear determination or an incorrect determination of "light/dark."

It is very difficult to put down a square dot, whether laser, inkjet, thermal, or other technology. Putting round dots close together can approximate a line, or a square. The word "approximate" is used deliberately as there needs to be some determination as to whether dots are aligned and intended to represent a straight edge, or whether they are spurious dots. As with the "light/dark" determination, some amount of threshold and interpretation is needed. Dot size and dot placement are crucial to the determination.

Two dots of equal size and overlapping so there is an obvious attempt at creating a straight edge are relatively straightforward to interpret. What happens if the dots are very different sizes so there is not a clear, orthogonal line to be interpreted along the edge? What if the dots are poorly aligned so the interpretation software struggles to understand whether there is a straight edge intended?

We are talking about infinitely small measurements and tolerances.

Dot sizes can vary for a wide variety of reasons. Labels can have a wide range of coatings. An inkjet dot could diffuse differently depending on the porosity of the material, the nature of the coating, and the formulation of the ink. Temperature and humidity can impact the electrostatic properties lasers use to regulate dot size. Thermal print head temperatures can impact the amount of resin or wax melted onto the label from the ribbon. Basically, whatever the print technology, variances exist that impact dot size.

To put it in perspective, a 203 dpi dot is 5/1000th of an inch in diameter. In the industry we use "mil" as 1/1000th of an inch. Said another way, a 203 dot is 5 mil. A 300 dpi dot is 3.3 mil and a 600 dpi dot is 1.67 mil. Barcode discussions are typically referred to in mil. We are talking about infinitesimally small measurements and tolerances. Variances of 1 mil in size or placement can significantly impact the interpretation.

A double line of dots has a higher chance of being read as a line compared with a single line of dots. Three side by side is better, and so forth. Most barcode readers use a double line of dots as the minimum suggested read size. A 10 mil barcode represents a double wide line of dots at 203 dpi, 3 lines of dots at 300 dpi, and 6 lines of dots at 600 dpi. Many scanners recommend the use of 10 mil as the minimum bar width to accommodate a wide range of printer technologies and densities.

Trying to line up a bunch of round dots to create a straight line perfect to 1/1000th of an inch is not without its challenges. Even with decades of dedicated engineering to reduce variability and eliminate defects, the random dust particle, or a mechanical/electrical glitch will always be a variable impossible to control completely. Said another way, there is a very good chance that some malformed barcodes could be generated in a batch.

Even if the barcode is perfectly formed, it can still fail. To avoid extraneous characters or dots from being interpreted as a barcode, there needs to be a "quiet zone" around the barcode so the interpreter can determine that the dot it is reading is from the barcode and not a text character or a blotch on the paper. Merely placing a perfectly formed barcode in the wrong place – too close to an edge, too close to a line, too close to text – can result in the barcode failing.

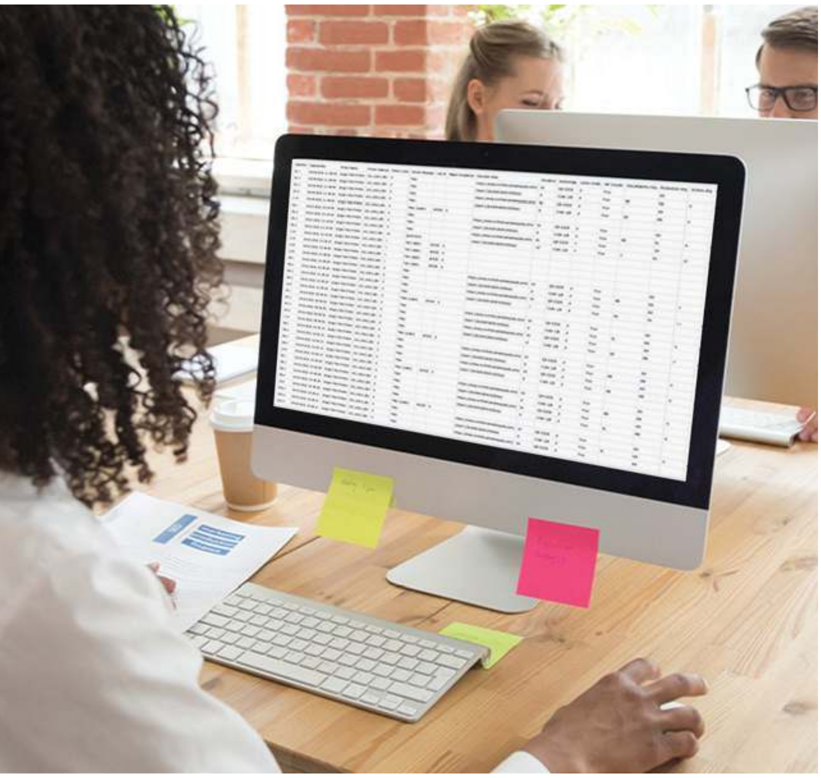
It is possible to have an entire eBook on just the causes of barcode grading failures, but that is outside the scope of this eBook. Let's summarize by simply saying that barcodes can and will fail on occasion.

What Happens When Barcodes Cannot Be Scanned? Impact of Poor Barcode Quality

A large retailer or manufacturer receives hundreds of pallets per hour in the warehouse or distribution center. Managing the flow of incoming trucks, scheduling forklifts, and recording each incoming pallet requires carefully planning and choreography. Disruptions to this workflow have become all too evident today with hundreds of ships moored off ports, empty shelves, product delays. With the volume of goods moving through the transportation and logistics systems, receiving docks are increasingly turning to automation to speed materials handling. Robotics and automated systems are highly dependent on the quality of the incoming barcode to enable them to move incoming pallets to the right location.

An unreadable barcode stops the process. Pallets that are unidentified block other incoming pallets, require manual intervention, and gum up the works. The problem is sufficiently acute that many companies that receive high volumes of goods impose penalties to discourage their suppliers from sending in poor quality labels. These penalties may be to reject the shipment, issue a chargeback to the supplier, demand a quality audit at the supplier's shipping location, or even cancel the supplier contact.

A barcode may eventually be able to be scanned, but still fall below the receiver's quality specification. How can that be? The topic will be further discussed below, but barcodes are graded based on readability. High-volume receiving warehouses cannot afford time to try again and again to get a successful barcode read. They need barcodes to scan the first time, and many assign a minimum quality grade to the barcode. As a supplier, if you merely scan a barcode and don't grade it, it may well fall below the minimum quality established by your customers and incur penalties for impacting their productivity.



Conversely, merely checking the barcode grade may fail to catch content errors. A software bug, or a database record issue, or other problem could result in a perfectly formed barcode that contains incorrect information. Grading alone will not catch these. You want to both grade and check the barcode for content.

If I Cannot Prevent a Barcode Failure, How Do I Catch It?

Obvious failures might be caught by someone looking at the label, but issues with alignment, decodability, axial conformity, modulation, or other defects require a barcode scanner to catch. The question becomes when and where to scan the label.

Before or After?

The choices are either after the label has been applied to the target (could be carton, product, and so on), or before the label has been applied. If the decision is after the label has been applied, there needs to be a way to divert the entire package from the process flow so it can be returned to the label station and have a new label printed and applied. This typically involves linking the scanner to a server that will evaluate the barcode, determine whether the barcode is acceptable, and then having a way for the server to control a switch or other means of flagging a box that needs to be removed from the flow.

Checking the barcodes before the label has been applied has the advantage of removing only the label from the process flow and reprinting the label without the necessity of physically moving the box the label is applied to, potentially minimizing operator intervention or investment in recirculation lines within the conveyor system.

The question becomes when and where to scan the label.

External Scanner versus Integrated Scanner

Checking the label before applying it to the target offers yet another choice: check the label external to the printer or check the label while still inside the printer. Checking the label outside the printer involves an external scanner or periodic spot checks by an operator with a handheld scanner. Periodic checks require dedicated operator time and will check only a fraction of the labels generated. An expensive alternative for a less than complete solution.

An external scanner has several considerations, including the necessity of running the paper path through the scanner after the printer, complicating any label changes or other paper path action. An external scanner requires additional space beyond the printer footprint. As many of these printers are next to conveyor systems with minimal space available, an external scanning station represents effort and space that are likely in short supply.

An external scanner needs to have some way to identify what areas of a label to inspect for a barcode. This is most typically done using a template that identifies the location of the barcodes to be scanned. The creation of a template may require the use of a PC, monitor, and keyboard that is also used for running the scanner code. This PC, monitor, and keyboard also require power and space in this same space-constrained environment, not to mention the expense of these components.

Each label design requires its own scan template to identify the barcode locations for that design. A corporation with dozens or hundreds of label templates must ensure that any change to the template designing the label for print must also be incorporated into the scan template as well. The coordination of these scan and print templates is essential as well as ensuring that the correct scan template is loaded with the correct print job.

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If an external scanner identifies a label as bad, there has to be some means of highlighting that label so it is not used. Since the label has already left the printer, there is no convenient way to mark the label, so the next best alternative is to have an internal connection to the printer so the scanner can halt the print process and possibly flash a signal light. This is an indication for an operator to remove the failed label from the scanner, and to then reprint the label. Operator intervention is required for the removal of the label and the reprinting of the label job.

Integrated Scanning Alternative

If the scanner is integrated inside the printer, the printer controller communicates the location of every barcode to the scanner, obviating the necessity of creating any templates for the scanner to find the barcodes. The elimination of template creation also eliminates the necessity of a PC, monitor, and keyboard. Since the integrated scanner uses microprocessors in the printer, no external equipment is required. With no external PC and no external scanner needed, the entire process is contained within the printer footprint system.

The integration of the scanner with the printer has other advantages as well. If a label is defective, no operator intervention is required. The scanner can signal the printer to retract the failed label, overstrike it so it cannot be used, and reprint the failed label automatically as all the label information is in the printer already. Additionally, all the grade and content data from the barcode is fed back through the same connection the printer is on, providing a single source control for an application to query printer status, but also get RFID or barcode information directly from the printer. This will be discussed in greater detail in the Reporting section below.

Summary

Integrating the scanner with the printer provides the lowest cost alternative requiring the smallest footprint while providing the most complete capabilities with the lowest operator intervention or effort.

Validation versus Verification

These two terms are often used interchangeably but do have different objectives. Barcode verification is the process of using an ISO standards-based set of metrics against the barcode to grade the quality. These include for 1D barcodes:

- Symbol Contrast: Difference of black bars and white spaces
- Minimum Reflectance: Check if dark bars have enough difference between background
- Edge Contrast: The least distinct difference between light and dark
- Modulation: Variation of light/dark contrast across the barcode
- Defects: Presence of light in the dark areas, dark marks in the light areas
- Decode: Check light margins on each side of the code

Each parameter is measured and assigned a grade from 1 to 4. Each barcode is sampled 10 times and the final grade is reported in a range from 4.0 to 0.0. To enable a more relatable way to understand quality, a letter grade A-F is assigned as follows:

Letter Grade	Number Grade	What This Means
A	3.5 – 4.0	Scan easily first time with most scanning equipment
B	2.5 – 3.5	May read after a single scan, second scan likely to read
C	1.5 – 2.5	Minimum quality level, re-scanning maybe necessary
D	0.5 – 1.5	Some scanners may fail to read
F	< 0.5	Highest failure rate, unlikely to read

Many companies that receive high volume of incoming components or items will insist on a grade B or better.

Barcodes using 2D symbologies, such as QR codes, PDF417, DataMatrix, and others, are graded on the following parameters across multiple samples to achieve the letter grade assessment:

- Symbol Contrast: Difference of black bars and white spaces
- Modulation: Variation of light/dark contrast across the barcode
- Decodability: Width accuracy of bars and spaces
- Fixed Pattern Damage: Measure of damage to detection patterns
- Axial Non-Uniformity: Measure of grid spacing in horizontal/vertical planes
- Grid Non-Uniformity: Measure actual grid against ideal grid
- Unused Error Correction: How much damage before unreadable
- Barcode Grade: Lowest score of each measurement

Both barcode validation and barcode verification are important for different objectives and should both be available for every barcode generated.

Verification is the process of assigning an objective measurement for barcode readability. A barcode verification grade is often used as the determinant for chargebacks, so it is important for anyone creating barcodes to understand what grade their barcodes are to avoid issues downstream. With integrated inspection, it is possible to automatically overstrike and reprint failing barcodes to ensure that only passing barcodes are applied to outgoing shipments.

While having a measurement of the quality of the barcode is important, it is also essential to check barcode content as well. Reading the content of the barcode (Validation) provides the opportunity to ensure that the lot number, zip code, or other information on the barcodes matches the contents. Reporting not only the barcode verification grade, but the barcode information such as symbology and content provides a more complete audit report if needed.

Both barcode validation and barcode verification are important for different objectives and should both be available for every barcode generated. The TSC Printronix Auto ID ODV-2D system provides both, including all of the individual verification parameter grades, the overall numeric grade, overall letter grade, symbology, orientation, and content for each barcode up to 50 barcodes on every label.

How Do I Enable Barcode Inspection?

An integrated barcode verifier, such as the TSC Printronix Auto ID ODV-2D option on the T8000 and T6000e printers, requires no templates, no special setup, no datastream conversions, and no operator intervention. You submit a print job, and ODV-2D finds, scans, grades, and reports the barcode automatically. Yes, it really is that simple.

What About Different Print Languages?

In the thermal printer industry each manufacturer has its own native print language creating complexity in mixed brand environments. Additionally, Postscript and PDF print files have become more widely accepted. The Printronix Auto ID Architecture (PSA) accepts jobs in any of these competitor printer formats, and will find and grade all barcodes without conversion or change. This flexibility provides the easiest implementation enabling "drop and go" implementation of barcode inspection into existing applications and environment.

It is highly recommended that testing be done to optimize the settings and configurations, as well as ensure that all print jobs are properly structured and compatible, but the design concept of simple operation is evident in the ODV-2D architecture.

Reporting

While ODV-2D will overstrike and reprint a failing barcode, it is prudent to be able to demonstrate label status before the label is shipped. If a regulatory agency audits for periodic inspection, it is helpful to have a report outline inspection on every label. If a retailer issues a chargeback for unreadable barcodes on a specific label, it is helpful to be able to show the grading report for that specific label that demonstrates it left the warehouse at a passing grade. If a customer wants to know the status of their order, it is helpful to be able to identify the exact date and time the label was created along with the tracking number to enable the carrier to trace the order. Saved data may mean saved money.

Capturing Data

ODV-2D automatically captures the data from every barcode it finds. One method of getting the data is to use PrintNet Enterprise (PNE), a package downloadable from the TSC Printronix Auto ID website at no charge. PNE offers tools for printer management, capturing printer statistics, and getting the data from ODV-2D. A report generator enables fields to be selected, the data format (.csv or XML), the file name and location to store the data to, and the time each day the data will be downloaded. PNE provides a straightforward means of getting a daily dataset with all the ODV-2D information contained within it.

Many customers want the job, label, barcode, and RFID information in real-time directly to their application.

Software partners also offer job, label, RFID, and barcode information integrated into their applications. One example is LABEL ARCHIVE by TEKLYNX. This solution automatically captures the job, label, and barcode information into a database connected to the print job. All the information about the template used, job submit time, and job results are combined nicely into a searchable database for easy retrieval. For more information about LABEL ARCHIVE, visit www.teklynx.com.

Perceptor PTXL from Perceptor Inspection Technologies, part of InterVision Global, also captures all the job information in a centralized database as well as checking for any duplicate or missing serial numbers from the print job. It provides centralized print job control for any number of printers throughout the world through a single managed queue. For more information about Perceptor PTXL, visit www.perceptor-ptxl.com.

Many customers want the job, label, barcode, and RFID information in real-time directly to their application. They would like to be able to dynamically provide printer setup instructions, change parameters, get hardware and connectivity information, and get all the job, label, barcode, and RFID information on every label as it is printed. This is possible using PXML, a structured query language integrated into PSA. Using some simple queries, all the ODV-2D data is returned to the application where the application parses out what it wants for storage, analysis, and action. The process of creating this linkage is the subject of another eBook.

However the data is captured, the key is that the data is available in the future as needed. ODV-2D not only ensures outgoing labels conform to your customer's specifications but provides the data to demonstrate it for audits or chargeback defense.

Applicable Industries

The simple rule is that if you make something, you inspect it. Inspect the label too.

ODV-2D has been particularly well leveraged by manufacturers of retail products, including clothing, consumer goods, and hard goods. Retailers, as well as the manufacturers themselves, are faced with COVID-19 related warehouse staffing restrictions resulting in stressed conditions through the supply chain. Retailers are aggressively implementing chargebacks to encourage suppliers to adhere strictly to the receiving guidelines. ODV-2D has proven a cost-effective way to reduce or eliminate retail chargebacks for suppliers of retail goods.

It has not only been retailers that have faced warehouse capacity bottlenecks and are issuing chargebacks or other means to maintain adherence to their receiving requirements. Any manufacturing facility where subcomponents from suppliers are assembled into a finished good have also implemented means to enforce smooth receiving operations. The simple rule is that if you make something, you inspect it. Inspect the label too.

Worldwide regulatory agencies have also taken action to enforce label standards. Incorrect, inaccurate, unreadable, or incorrectly formatted labels on medical devices, chemicals, pharmaceuticals, military equipment, and foods are not only inconvenient, but could cause serious harm or death. Medical devices, for example, are required to have a globally unique serial number to aid in identification in the event of recall, or patient follow-up. A mislabeled drug or chemical could prove fatal. In these industries the regulatory agency may impose severe penalties for non-compliant (including unreadable) labeling. For suppliers in regulated industries, the stakes are even higher so the incentives greater for label inspection.

Outlook for the Future

Unreadable, incorrect, or non-compliant labels will cause pain indefinitely, probably with greater impact as automation is increasingly used to shore up the supply chain issues identified in the pandemic. Regulation is more likely to increase than decrease. Label inspection, therefore, isn't going away anytime soon in the foreseeable future. If anything, demand for label inspection will grow.

Labels come in a wide range of sizes, and label inspection will be asked to accommodate standard label sizes, from extremely small labels for electronics to very large labels for pallets. This will necessitate scanners that can cover typical widths up to A4 or 8.5" and can also read increasingly small barcodes to fit on shrinking package sizes.

Data capture, analysis, and retention is going to become increasingly mandated. With readily available data from the scanner, applications will increasingly check for things like duplicate or missing serial numbers, missing or misplaced cautionary symbols mandated in regulated industries, label content validation, and to ensure that the label complies with increasingly complex regulations for every country on its journey.

Constants, however, include the requirement to minimize cost, risk, and effort. Integrated inspection provides the best potential to reduce all three and will remain the optimal solution for the future. One additional constant is the importance of print quality. Printing a label that is going to be rejected is dull. Printers optimized to meet extremely tight tolerances of print quality will be essential as barcode grading moves to smaller and smaller mil sizes. Integrated scanning also radically simplifies repair and rapid deployment of printing locations worldwide, vital parts of the supply chain process.

As the importance of label inspection increases, so will the demands for high quality print output and integrated scanning. Be sure to find a partner you trust.

Conclusion

Barcode failure impacts many people downstream and will probably result in that pain being shared with the sender. Barcode inspection offers easy and inexpensive insurance to avoid issues and capture helpful data. Integrating the scanner with the printer provides the most effective solution to minimize cost, space, and labor to provide 100% inspection on every barcode on every label. Printronix Auto ID, part of the TSC family, has been building integrated label inspection systems for over 20 years and has earned the trust of leading companies around the world. For more information about TSC Printronix Auto ID's ODV-2D integrated scanning system, please contact your local reseller or your local TSC Printronix Auto ID territory manager, or visit www.tscprinters.com.

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