The Basics of Bar Coding

A P P L I C A T I O N W H I T E P A P E R

C O N T E N T S

Thermal print technology is an excellent choice for many bar code and label printing applications, and should be well understood by any company considering a bar coding system. This white paper will explain the principles of thermal bar code print technology and will enable the reader to identify when its application is most appropriate compared with alternative technologies.

BAR CODING BASICS

Overview

Automatic identification and data collection (AIDC), also known as Auto ID or Keyless Data Entry, is the generic term for a number of technologies that help eliminate human error and reduce time and labor by replacing manual methods of data entry and data collection. Bar coding is one of several AIDC technologies that also include magnetic striping, smart cards, radio frequency identification (RFID), and Wireless LANs (WLANs). Bar coding is a fast, easy and accurate data entry. Once bar-coded data is collected via a bar code scanner, activity can be tracked efficiently and accurately at speeds not possible using manual data entry and reading systems.

Bar codes, such as the familiar universal product code (UPC) symbol used on packaged goods, first appeared in grocery stores in the early 1970s. Aided by new technologies such as mobile and wireless printing, bar coding has evolved into a productivity enhancement tool widely used by business and industry for collecting and processing information. Zebra Technologies, for instance, brings bar coding to a variety of companies in manufacturing, distribution and fulfillment, hospitality, education, travel, retail, security and healthcare.

Bar codes are fast. Speeding both data entry and data collection, they allow instantaneous, real-time data capture and exchange. Bar codes are also accurate. Studies show that the entry and read error rates when using bar code technology is approximately one error in one million characters, vs. one error per every 300 characters using manual key entry.

Bar codes permit companies to track information and activity as it occurs, allowing their decisions to be based on concrete, current, and accurate information.

Bar Code Design

Bar codes encode data—such as part number, serial number, supplier number, quantity, or transaction code—into the form of black and white stripes or "bars." A number of bar code standards have been developed and refined over the years into accepted languages called "symbologies."

Bar code symbologies can be either linear or two-dimensional. A linear bar code symbology consists of a single row of dark lines and white spaces of varying but specified width and height, as indicated by the example below.
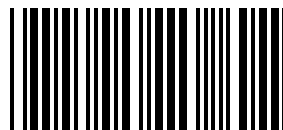
Linear bar code

2-D bar codes "stack" information to allow more information to be stored. They are configured either as stacked linear bar codes, or as matrix symbols that use regularly shaped black or white cells to encode data. A one-inch by one-inch 2-D matrix symbology can encode and store the entire U.S. Constitution!

2-D symbology

Bar Coding System Requirements

To establish a bar code system for AIDC, four primary components are required. They are a *bar code printer*, a *label* for item tracking, *scanning equipment* for data collection, and an *external database* for bar code data capture and relay.

Component 1 - The Bar Code Printer
> Bar codes are typically printed by one of four types of printers: dot matrix, ink jet, laser, or thermal. They will be discussed in detail in Section 3, entitled "Bar Code Print Technologies."

Component 2 - The Bar Code Label
> Labels are commonly applied on parts, product subassemblies, products, packages and shipping containers, allowing the item to be identified and tracked during internal processing or after it is shipped or sold. An item label can contain any combination of text, graphics, or bar code information, but it is the bar code symbology that facilitates the item tracking process.
> Bar code labels can be applied to anything—or anyone—that needs to be identified or tracked. For instance, hospital patients wearing barcoded wristbands have their ID scanned and matched with barcode labels on medical orders, charts, specimens, meals and medications throughout their hospital stay. Bar codes are not confined to adhesive labels, but also can be printed on receipt paper, tickets, tags and plastic cards, depending on the application and the selected printer.

Component 3 – Scanning Equipment for Data Collection
> In the data collection phase, scanners are used to instantly and accurately read, capture and decipher the information contained in the bar code label. Scanners read information much faster and more reliably than humans, thus significantly reducing the likelihood of error. Scanners also act as decoders, converting bar code information into a signal that can be understood by a computer system linked to a scanner.

Component 4 – Data Capture Via an External Database
> The fourth and final component of a bar code system is the external database. Bar code applications commonly rely on the availability of external-data computer systems to match an item's unique bar code with pertinent information about the article from a related database. The computer mainframe collects and interprets the data transmitted from the scanner and links the bar code information to a detailed data file on that item. Such data files contain information such as a detailed product description, price, and inventory quantity, enabling transactions and activity to be monitored in real-time. Without this external database, the bar code can have no value.

Key Benefits of Bar Coding

Implementing a bar code system offers tremendous advantages. Among the most compelling benefits are:

Accuracy
> Bar coding increases accuracy by reducing the likelihood of human errors from mislabeled or misread items. Good print quality is important to ensure that the scanner can accurately read the bar code.

Ease of Use
> With the proper hardware and software in place, the automation provided by a bar code system greatly simplifies information collection, processing and tracking.

Uniform Data Collection
> Standardized bar code symbologies and compliance labeling ensure that bar code information is captured and relayed in a fashion that is universally understood and accepted.

Timely Feedback
> Data is captured in real-time, enabling decisions to be made from current information.

Improved Productivity
> Automation of formerly manual tasks increases efficiency and allows personnel to be employed in other, more productive areas. Bar coding also can improve a company's quality by improving the monitoring and tracking of manufacturing processes.

Increased Profitability
> Increased efficiencies from bar coding—such as improved workflow and reduced error rates—enable companies to save costs and improve their bottom line, as well as potentially improve sales through heightened customer satisfaction. In fact, the return on investment for an AIDC system is typically one year, and often substantially less.

Common Bar Code Applications

Generally, any industry or company can utilize bar coding to track and improve current processes and operations. The convenience of bar coding surrounds us in everyday applications, such as retail and package delivery, as well as in newer applications such as travel, hospitality and security. Some of the most common bar code applications are:

### Manufacturing Processes and Supply Chain Management

Manufacturing businesses depend on a well-coordinated chain of events to make their operations work effectively. Many companies initiated bar code labeling at the shipping dock to support their customers' compliance requirements. Today's ERP (Enterprise Resource Planning) systems depend on bar coding and data collection systems to provide information crucial to the entire manufacturing operation. Following are steps in the manufacturing process where bar coding is typically applied. The receiving, inventory, picking and shipping steps are equally applicable to distribution and fulfillment applications.

Receiving
> Raw materials or subassemblies arriving at a manufacturer's receiving dock from suppliers usually have compliance bar code labels on their packaging to meet the manufacturer's requirements. If not, the receiving department logs in the item and generates a bar code label to identify the material.

Raw Material/Parts Inventory
> Materials transferred to inventory locations are often identified with bar codes. The fork truck operator scans both the package and the storage location to record it in the system.

LOCATION: AISLE 12 BIN 1132

PolyPro 2000 Removable™
5095 Ribbon 3 ips
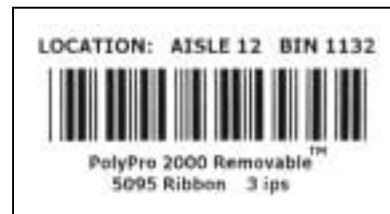
Sample - Inventory Control Label

Picking
> A work order from the factory floor signals the picking operation to retrieve raw materials or parts from inventory. When an item is removed from stock, the fork truck operator scans the shelf label, sending information to the mainframe computer to register the transfer and to update the inventory level. The computer recognizes when an item needs to be replenished, and can cause a purchase order to the particular supplier to be issued. In some cases, inventory labels need to be updated; mobile printers mounted on lift trucks simplify this operation.

Work-in-Process
> Bar codes on picked materials are scanned to confirm the right parts and quantities were picked. As the parts are used in the assembly process, bar codes enable part tracking throughout the process—showing that a part was consumed in an assembly. As parts become components,

additional bar code labels are added to enable the system to identify and track the assemblies by their new part numbers.

Labor Tracking

Bar codes for labor tracking of a manufacturing process ensure consistent quality and output. As the operator scans each part or subassembly added, the computer monitors it for correct specifications. Should an assembly be found faulty, it can then be tracked back to the exact day, time, workstation and/or person responsible for the error.

Product Identification

Bar code labels containing serial numbers, UL/CSA regulatory content and other data are used as nameplate identification. Such labels help companies in asset tracking operations—allowing them to track products once they are leased or sold.

Finished Goods

Once a finished product is packaged, bar codes are used to identify the contents. If no sales order for this product exists, the forklift operator collects the package and takes it to a finished goods warehouse. Bar codes on the product and the warehouse locations are scanned to complete the transfer. When a customer's sales order arrives, a similar process is used for picking the proper products. Scanned bar codes confirm the correct items were picked and record the transfer to the shipping department.

Shipping

The package's bar code is scanned to acknowledge receipt in the the shipping department. Shipping labels printed in customer- or carrier-specific compliance formats are added. If a number of labeled packages are combined and shrink-wrapped on a pallet, a larger, master label is attached.

Bar coding has numerous applications outside of manufacturing, too:

Time and Attendance

Any company that uses timeclocks can provide employees with badges printed with bar codes. The bar codes, scanned at clock stations, can provide attendance data directly to a computerized payroll program.

Package Delivery

For common carriers such as UPS® or FedEx®, the bar code label enables the package to be tracked as it passes through diverse sorting hubs en route to its ultimate destination. Throughout the package's journey, each sorting hub scans the package to register its receipt before passing it onward. Thus, if the package is ever misplaced or its arrival delayed, it can be tracked by its bar code tracking number to the exact point in the process where it halted.

Route Accounting

For delivery of items like bottled water, for example, bar codes would be scanned throughout the process, from order receipt to loading to final delivery of the bottles, and again when empty bottles are picked up.
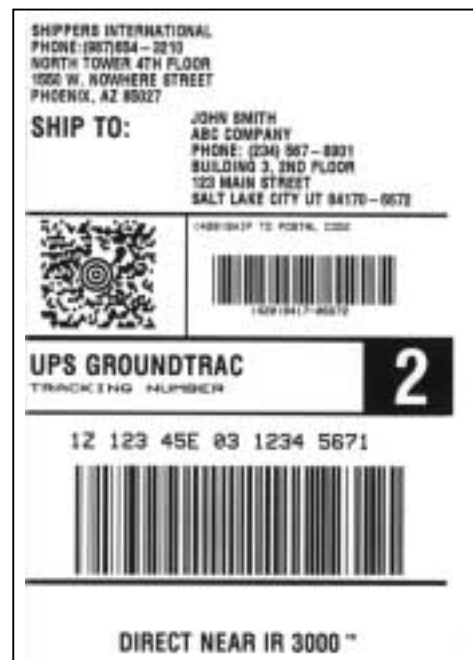
Healthcare

The use of bar coding in healthcare increases the accuracy of medication administration, provides management tracking and reporting tools, enhances documentation and ensures greater patient safety. From patient ID wristbands to specimen and prescription labeling, bar code printers and supplies offer dependable solutions.

Hospitality and Travel

Bar code label and receipt printing is frequently used for "queue busting." With shorter lines and fewer hassles, guests have more time to relax. Orders are processed more quickly so lines move faster and customers are served more quickly. Other bar code printing examples include airline baggage tags, amusement park wristbands, event tickets, and boarding passes.

Retail

Bar coding is used in retail applications for shelf labeling, product markdowns and even mobile point-of-sale. The most familiar application is the expediting of checkout, with bar code labels attached to products that are scanned during checkout and interpreted by a computer. The computer recognizes the bar code data and links the item to its price and to the description contained in the store's database. This product information is reflected not only on the sales receipt, but is automatically linked to the store's inventory tracking system, alerting it to deduct the quantity of the item purchased from the store's current inventory record. This entire process occurs in a matter of seconds with minimal data entry required by the checkout person.

Sample - Retail Item Labels

Security

Bar codes can be printed on plastic ID and keyless entry cards to aid in access control. In the airline industry, bar codes are being used to link baggage to passengers and to track the movement of people, luggage and cargo. Bar code labels are also used successfully in law enforcement to track evidence.

ASSESSING THE APPLICATION

Before you can select the right bar code system, it's helpful to assess your facility's labeling requirements. These include:

Process Requirements

What tasks require automating, specifically through the aid of a bar code label? What specific purpose will the label have? What process or steps will the label be required to go through? How, when and where will the label be applied and read? How long will the label need to adhere (*permanent vs. semi-permanent*) and last *(long-life vs. short-term)*? To what environmental conditions *(heat, cold, moisture, humidity, chemical bath, blood or direct sunlight)* might the label be exposed?

Compliance Requirements

What industry compliance label standards will likely dictate label format and content? Do you have any large customers that require labels that comply to certain standards?

Regulatory associations, such as ANSI (American National Standards Institute), CEN (Commission for European Normalization), DOT (Department of Transportation), or NFPA (National Fire Prevention Association); as well as industry groups such as EIA (Electronic Industries Association), HIBC (Health Industry Bar Code Council), and AIAG (Automotive Industry Action Group), have developed technical specifications and application standards for bar code use worldwide and within particular industries. Compliance standards are frequently established between trading partners in manufacturing and distribution operations to increase accuracy of information exchanged and increase efficiency throughout the supply chain. These can include:

Application Standards

An application standard is a set of policies and procedures that govern an application within an operation. Most operations have a defined set of rules to manage the material flow and manufacturing processes in their operation. These rules can be defined as an application standard.

Product Identification Standards

Product identification standards specify how to mark products and what information must be made available to consumers purchasing those products.

Sample – Product Identification Standard

Label Standards

Label standards (also referred to as *compliance labeling*) have been created for commercial applications so trading partners can easily communicate and conduct business transactions at a higher level of efficiency.

Sample – Compliance Label Standard

Depending on your industry, and your specific bar code application, conformance to one or more of these standards may be required.

Production Volume Requirements

Based on your compliance and tracking requirements, you must then assess your projected daily, monthly and peak label volume usage. Does it justify the cost of off-site label printing or on-site, on-demand printing?

Off-site vs. On-demand Label Printing

Whether you should buy preprinted labels or print them yourself on-site is a factor of how quickly the labels are required, where the information for the label is coming from, and how often it will change. Printed-label suppliers are best used for labels that are identical, constant, or contain data that is known in advance. Printed-label suppliers can produce labels with serial numbers or other simple variable data. Most will also need two or three days to deliver the labels, requiring planning to ensure that an adequate supply of labels is on-hand.

When labeling unique items, where the label has to be matched to the specific object it is to identify, buying pre-printed labels may not be practical, particularly for large quantities of labels without an obvious sequence. Here, the difficulties of applying the label to the correct object may preclude the use of a print supplier and make a good case for the use of an on-demand printer. On-demand label printing is also necessary when labels contain large amounts of variable data, or when the information, such as a lot number of date completed, is only available at the time the label is to be applied.

Budgets and Costs

Finally, your budget criteria must be analyzed. Specifically, what equipment, materials and/or personnel resources are needed to accomplish this task? What installation, operating and/or maintenance costs are involved? What are the warranty/service coverage options and supplies investment costs using a given print technology? Based on label volume and maintenance costs, how quickly can you anticipate a return on your investment (ROI)? Do you have management support for such a project?

Based on your answers to these questions, you are now ready to choose a bar code print technology to suit your application.

BAR CODE PRINT TECHNOLOGIES

The common bar code printing technologies are *dot matrix, ink jet, laser* and *thermal printing.*

Dot Matrix

Dot matrix print technology is one of the oldest techniques used for on-site label printing. The typical dot matrix bar code printer is a modified line printer requiring pin-feed paper stock. Solenoid-driven needles strike an ink-coated nylon ribbon, transferring ink onto the paper or label. The image is built up dot-by-dot in a matrix as the needle and paper are moved relative to one another.

Advantages

- Dot matrix printers are readily accessible and inexpensive to purchase.
- They can print on virtually any type of form, check or document and can print on wide-web, multi-part (carbon) forms.
- Dot matrix printers use multi-pass ribbons, which can result in reduced overall cost for ribbons and label material.
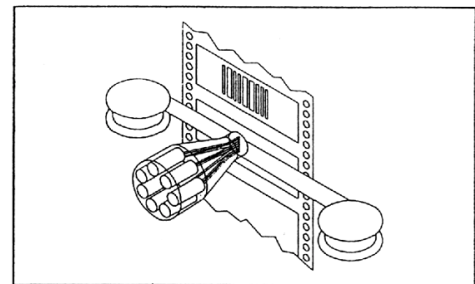
Dot Matrix Printing

Limitations

- Dot matrix printers print low- to medium-density bar codes that may not meet certain end-user guidelines. The dot size on the matrix printer limits the narrow element size and density of the bar code. The following example compares sufficient dot overlap vs. unacceptable dot overlap on a dot matrix printer used to print bar codes.
- Continuous ribbon re-use on dot matrix printers requires close monitoring of ribbon condition to ensure adequate bar code contrast. Ribbon ink that has become exhausted can also produce an image that is inadequate for scanning, resulting in a low read rate and high error rate.
- Ink saturation can result in paper "bleed" which can cause image distortion.

Sufficient Dot Overlap **Unacceptable Dot Overlap**
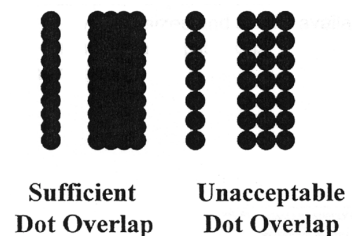
- A dot matrix-printed label is limited in durability. Dot matrix printers typically cannot produce chemical- or water-resistant labels.
- Printing of single labels results in significant waste. The design of the dot matrix printer's print carriage, sitting far below the media, also does not allow one to maximize the label space.
- Dot matrix printing offers no graphics printing capability.
- Bar code print speed is greatly reduced when best ink coverage for optimal print quality is specified.

Ink Jet

Ink jet printing is a common direct marking process and a favorite on high-speed production lines. Ink droplets are selectively deflected between a moving product and an ink return channel. Ink jet printing is used primarily for printing cartons or product packages with bar codes and human-readable data at very high speed.

Advantages

- Direct ink jet printing requires only one step, while label printing requires two: printing a label and then adhering it to the product.
- High-speed ink jet printing is a favorite on high-speed production lines due to its ability to mark "on-the-fly."
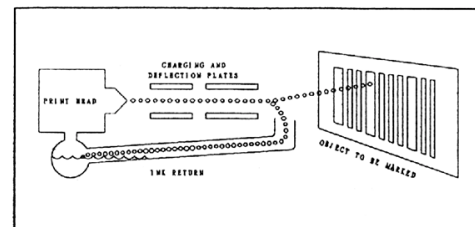
Deflection Ink Jet

Limitations

- System installation is costly because it is designed for high-volume bar code printing—not for individual or small-batch printing.
- Ink jet printing requires diligent supervision and maintenance to ensure consistent print quality and to prevent ink jet clogging.
- Dot placement accuracy and bar code density/resolution are limited due to ink splatters and because the print surfaces are in continual motion.
- The ink bleeds on some materials, restricting use to a limited variety of materials.
- Bar codes printed on the dark background of corrugated box materials suffer from poor contrast.
- Scanning devices must be carefully chosen to ensure reliable bar code reading.

Laser

The laser printer works much like a photocopier; it projects controlled streams of ions onto the surface of a print drum, resulting in a charged image. The charged image then selectively attracts toner particles, transferring the image onto the paper substrate by means of pressure. The pressure from the printhead and drum then fuse the image to the paper, creating the image.

Advantages

- Laser printers are good at producing plain-paper documents that require bar codes.
- They can print high-quality text and graphics on paper documents and can double as a document printer when not being used to print bar codes.
- Bar code density and resolution are also quite high on laser printers, resulting in a scannable code at virtually any wavelength using an infrared scanner.
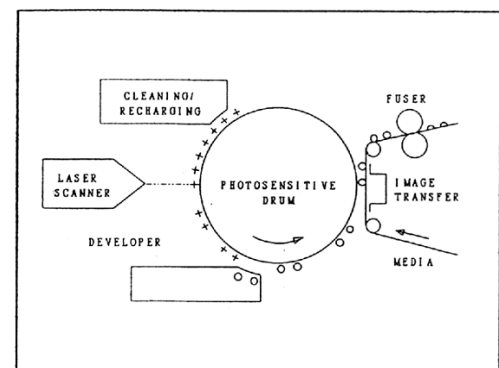
Laser Printing

Limitations
- Laser printers are not well suited for industrial or individual-product labeling applications. They can be wasteful, as they cannot produce single or small labels. A minimum of half a page of media is typically required for the printer to maintain control of the sheet. Unless the label is at least that size or multiple labels are needed at once, the remainder is wasted.
- Laser printer label adhesives must be carefully selected to ensure stability under the heat and pressure of the fuser. Otherwise, the adhesive may extrude onto the printer mechanism, where it will capture stray toner, or may cause the labels to curl at the edges. Because of the pressures used in the laser printer image transfer process, many laminated label materials are not compatible with this technique. Those materials that are compatible may not always be available in the sheet form necessary for laser printing.
- A laser-printed paper label has limited durability. Laser printers cannot produce chemical- or water-resistant labels and images, for example.
- With laser printers, toner, drum and supply costs can skyrocket when printing bar codes instead of typical text. While text requires only about 5% black, bar code needs can exceed 30%. Toner costs alone could be six times higher when printing bar codes rather than text.

Thermal

Thermal printing is classified as either direct thermal or thermal transfer. The two technologies are suited to different applications.

Direct Thermal Printing

Direct thermal printing is an old technology, originally designed for copiers and fax machines, that utilizes chemically coated paper. It has since been transformed into a highly successful technology for bar coding. The direct thermal printhead consists of a long, linear array of tiny resistive heating elements (about 100 to 300 per inch) that are arranged perpendicular to the paper flow. Each printhead element locally heats an area directly below it on the chemically coated paper. This produces a chemical reaction that causes a black dot to form in that area. The image is built by rows of dots that are formed as the media passes beneath the active edge of the printhead.
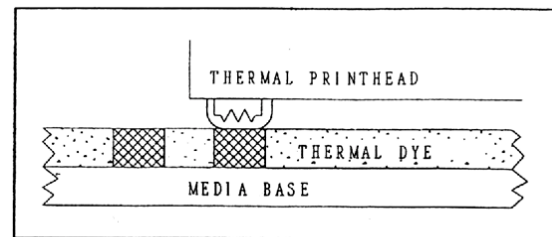
Direct Thermal Printing

Advantages
- Direct thermal printing produces sharp print quality with good scannability.
- Direct thermal is ideal for applications requiring only a short shelf life—meaning the label image does not need to last very long. Shipping labels and receipts are ideal applications, for instance, while product labels are not.
- Direct thermal printers are simple to operate compared to most other print technologies, with no ink, toner or ribbon to monitor or replenish.
- With no supplies to replace other than the material to be printed, long-term maintenance costs remain low.
- Direct thermal enables batch or single label printing with virtually no waste.
- With recyclable materials available, direct thermal printers offer environmental economy.
- Direct thermal printers, like thermal transfer, are typically built more durably than dot matrix or laser printers, allowing reliable operation in industrial as well as office applications. Shorter label image life limits their applications compared to thermal transfer printers, however.
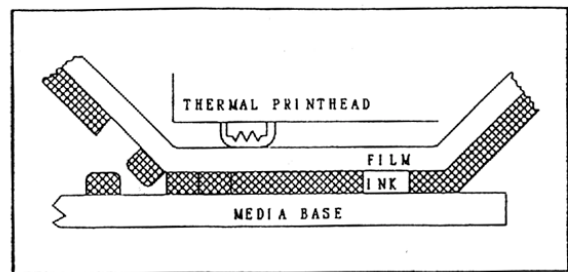
Limitations
- Direct thermal printing is extremely sensitive to environmental conditions such as heat and light (fluorescent and/or direct sunlight).
- Direct thermal paper remains chemically active after printing. Because of this, thermal labels, tags or ticket stock are often top-coated to resist UV light exposure, chemicals and abrasion.

Thermal Transfer

Thermal transfer printers use the same basic technology as direct thermal printers, but replace the chemically coated material with a non-sensitized face stock and a special, inked ribbon. A durable, polyester ribbon film coated with dry thermal transfer ink is placed between the thermal printhead and label. The thermal printhead transfers the ink onto the label surface, where it cools and anchors to the media surface. The polyester ribbon is then peeled away, leaving behind a stable, passive image.

Advantages
- Thermal transfer delivers crisp, high-definition text, graphic, and bar code print quality for maximum readability and scannability.
- Thermal transfer printing produces long-life image stability.
- Thermal transfer enables batch or single label printing with virtually no waste.
- Long-term maintenance costs are low compared to dot matrix, ink jet and laser printing.
- Thermal transfer technology can print on a nearly unlimited variety of media stock (except multi-form).
- Thermal transfer printers are typically built more durably than dot matrix or laser printers, allowing reliable operation in industrial as well as office applications.

Thermal Transfer Printing

Limitations
- Since thermal transfer printers require ribbon, supply costs are higher than direct thermal. Thermal transfer printheads last longer than direct thermal, however.
- Single-pass thermal transfer ribbon can be wasteful if little is printed on it.
- Thermal transfer ribbon is a poor candidate for recycling.
- To obtain optimum print quality in thermal transfer printing, the ribbon and media substrate MUST be compatible. Otherwise, the heat from the printhead could melt the ribbon onto the label causing internal printer problems.

BAR CODE PRINT TECHNOLOGY MATRIX

Technology	Print Quality	Scanner Readability	Initial Installation Cost	Long-Term Maintenance Cost	Materials Waste
Dot Matrix	Fair	Low	Low/Moderate	Moderate/High	High
Ink Jet	Moderate	Low/Moderate	High	Moderate/High	High
Laser	Moderate	Moderate	Moderate/High	Moderate/High	High
Direct Thermal	Moderate/ Excellent	Moderate/ Excellent	Moderate/High	Low	Low
Thermal Transfer	Excellent	Excellent	Moderate/High	Low	Low

WHEN TO SELECT THERMAL PRINTING

Direct thermal or thermal transfer printers are best when you need any of the following:

Point-of-Application System

"Point-of-application" means the printer is located where the label is to be applied. By printing labels where needed and when needed (on demand), thermal printers can increase productivity. Point-of-application printing is related to distributed printing, whereby printers are placed at various points throughout a facility. Thermal printers are smaller, simpler, more durable and less expensive than laser or dot matrix printers, making them ideal for distributed printing.

Variable Data

Thermal printers are ideal for applications that require individual or batch labels with variable data fields that change frequently. In such cases, thermal printers promote efficient and flexible label production with virtually no label waste, enabling users to print only what they need when they need it.

Varying Label Sizes

Thermal printers are ideal for labeling applications requiring varying label widths and/or lengths because they adapt easily to a variety of label sizes. (In fact, on thermal printers with wide print widths, labels of assorted sizes can be printed at once.) Laser and dot matrix printers cannot make such claims because the variety of label materials and sizes in sheet or pin-feed format is limited.

Graphics and Scalable Text Font Sizes

Thermal printers can cleanly print any graphic image, including logos. Additionally, text fonts are "scalable," meaning that they can be adjusted to any point size requirement. (Bitmap fonts, by comparison, are only adjustable to a limited number of point sizes—e.g. 8, 10, 12, 14, 16 or 18 points). Laser and dot matrix printer software do not allow such flexibility.

High-definition Bar Codes

Thermal printing is ideal where high-definition bar codes are required. Bar codes printed on direct thermal printers—including complex, 2-D bar codes—offer the highest first-time scan rates of any printing technology, reducing errors and increasing productivity.

Compact Printers

Thermal printers are clean and quiet, and more compact than dot matrix, ink jet or laser printers. Thermal printers come in three basic varieties—tabletop, desktop and mobile. Tabletop thermal printers are bigger than desktop thermal printers, primarily because of their ability to hold a full 8" roll of media compared to the 3"-5″ roll capacity of a standard desktop printer. (Larger roll capacity enables users to print for a longer time without changing media, boosting productivity in high label print volume applications.) Mobile printers are the smallest of all because they are designed for portability, often hanging from a shoulder or belt strap.

Even tabletop printers that are comparable in size to some laser printers usually are designed to have a smaller "footprint"—the amount of flat surface area that is consumed. Desktop printers have a footprint about the size of an office phone or mouse pad. Only thermal printing technology offers the compact portability of mobile printers.

Low Operating Costs

Thermal printers tend to have a higher initial cost but a lower maintenance cost compared to other print technologies, resulting in a lower cost of ownership. Lower long-term maintenance costs can quickly offset the higher initial investment.

CHOOSING THE RIGHT PRINTER

Once you've decided that thermal printing is right for your needs, you can analyze which thermal printer model is best suited for your application based on the following performance variables:

Printer Durability

What sort of environmental conditions will the printer encounter? Some Zebra printers, for example, are specifically designed for harsh industrial environments with sealed cabinetry to prevent dust from interfering with operations. Rugged desktop printers may be ideal for light industry, commercial applications and office use.

Print Volume

What is your daily label output? Zebra's High Performance *Xi* Series printers are designed to operate continuously, during peak print cycles or non-stop for 24 hour cycles. Other models are better suited for lower volume, intermittent printing. Print speed is also a factor in meeting print volume requirements.

Print Speed

Print speed is an important consideration if you require a high volume of labels to be printed daily or during peak cycles. That is because print speed is an element of "throughput": the time lapsed between receipt of the print command and completion of the printing process. Throughput depends not only on printing time, but also on label formatting time: the time required to convert the program and data to an image on the label. Depending on the complexity of the label format and the printer's ability to process this information in an efficient manner, label-formatting time can sometimes cause significant print delays, affecting a printer's overall print speed capability. Such delays can be costly in productivity if they occur in a production environment where time and on-demand print capability are of the essence.

Label Image Durability

Thermal transfer is the only alternative if crisp, long-lasting images are required to last for a number of years. Direct thermal printers, in comparison, are ideal for short-term applications where the label is only required to last for a limited amount of time—from one week to one year. Direct thermal is not as durable as thermal transfer, especially when exposed to direct sunlight or chemicals. Direct thermal paper varieties are also somewhat more limited than those available for thermal transfer printers.

Print Resolution

Depending on your application, higher resolution (measured in dots per inch or DPI) may be required to facilitate the printing of text and bar codes on very small labels, such as those commonly used in the electronics or pharmaceutical industries for component or specimen labeling. Higher print resolutions provide crisp, detailed printing of much information in small spaces, without impairing scanner readability. While many Zebra printers have 203dpi resolution, plenty for normal applications, certain models offer 300dpi and even 600dpi for high-resolution printing.

Print Width

Another factor in choosing a printer is determining the widest label you will need to print. Zebra thermal printers, for example, offer an assortment of maximum print widths ranging from 2" (on mobile and some desktop printers) to 8.5" (for printing 8-1/2"x11" packing slips and invoices faster and less expensively than laser printing).

If your application demands large labels (e.g., shipping labels; multi-part invoices; or labels on large products and packages, chemical drums, pallet wrap) you'll need to choose a wide-label printer with a print width of 6" or more.

Even if the application does not require large labels, sometimes a wide-label printer can still be advantageous. For example, while a 4" printer is able to print the common 6"x4" compliance label format, it must rotate the information and print it lengthwise (4"Wx6"L). A 6" printer can print the same label laterally (the wide way) as 6"Wx4"L.

In the 4″Wx6″L format *(far right),* the bar code is shown in a rotated, "ladder" style format. The 6″Wx4″L bar code format is shown in a normal, "picket fence" style. It is more difficult for most printers to print rotated bar codes; rotated labels have to print more slowly to achieve the same bar code print quality. Zebra's patented E^3 printhead technology ensures that the correct amount of heat is delivered to each part of a printhead at all print speeds, optimizing the quality of the bar codes that are produced in either orientation.

Above—6Wx4L format;
Right —4Wx6L format (rotated)

A 6" printer will complete a 6"Wx4"L label three times faster than a 4" printer, and will produce 50% more labels from a single media roll—saving media costs and stretching the time between media changes.

Wide-label printers can also multitask, with "multiple up" printing. Using a single printer configured to print multiple formats, for example, an assembly station can print on demand all the component labels it needs for each assembly. Similarly, wide-label printers allow "multiple cut" printing that is valuable for batch printing: a 6" printer can print six 1" die-cut labels across simultaneously.

Printer Feature Options

Additional factors to consider when purchasing a particular thermal printer are its available options. These options may include:

- Different print modes: label cutter; peel; liner take-up; tear; rewind, etc.

- Real-time clock for printing the time and expiration date

- Advance counter for alerting users when it is time to change media, do preventive maintenance, etc.

- Communication options: parallel; serial; USB; twinax or coax cables; wired or wireless Ethernet, etc.

- Memory options: PCMCIA/Flash memory; upgradeable DRAM

- Font options: Scalable vs. bitmap; non-Roman Asian font sets for international characters such as Chinese and Japanese; TrueType® fonts, etc.

Any of these options can help the printer meet application needs more closely and enhance the operator's productivity. The peel mode option, for example, can facilitate quicker label application. In peel mode, the printer will separate the label from its liner backing—so rather than removing it manually, the user can simply grab the label and adhere. Such time-saving options can greatly facilitate label output and in some cases even improve worker morale.

When a proper balance is reached between printer performance and application, the printer becomes a more natural extension of the operator. The resulting higher efficiency can add to the organization's overall productivity and bottom line.
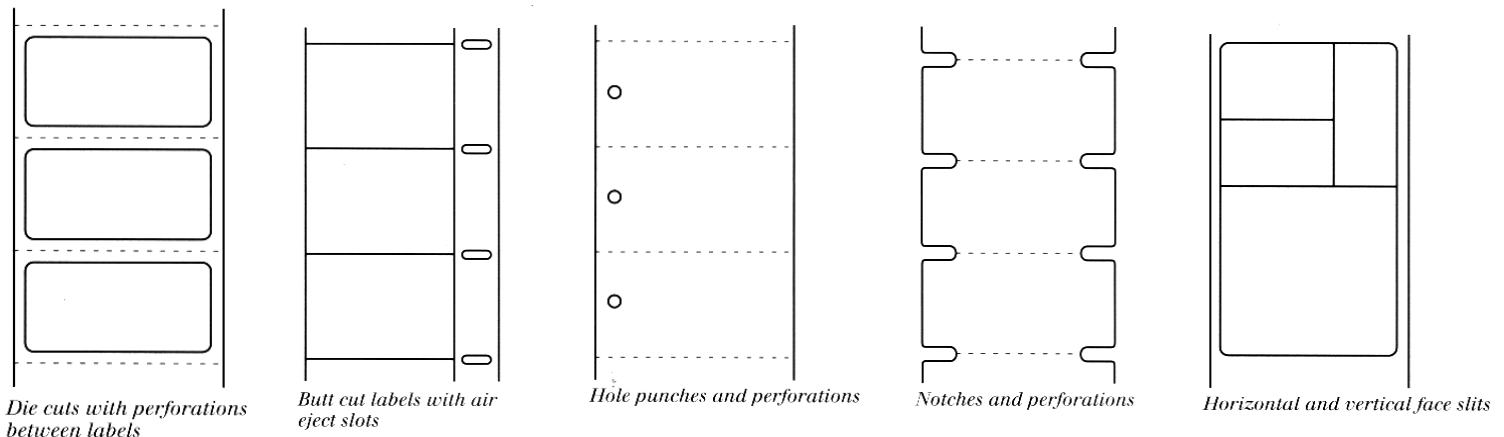
CHOOSING THE RIGHT SUPPLIES

How do you choose the right materials to work with your thermal printer to guarantee optimal printer performance and consistent print quality? The key to specifying the correct media, similar to the correct printer, involves a solid understanding of the application. Zebra recommends analyzing the following supplies-related issues in conjunction with your thermal printer selection:

Direct Thermal vs. Thermal Transfer Print Technology

Selection of label material depends first on whether *direct thermal* or *thermal transfer* print technology is chosen to satisfy the application requirement. For optimum printer performance and to extend the life of the printhead mechanism, it is important to select the right media (or the right media and ribbon combination in the case of thermal transfer printing). Choosing the wrong media can result in poor print quality, printer malfunction and/or frequent printhead replacement. Your local Zebra reseller or Zebra Supplies Specialist can assist you in choosing the right thermal materials to operate with your printer.

Media and Calibration Methods

Thermal printers are designed to operate with a variety of media types, including *pressure sensitive, die-cut, butt cut, perforated, notched, hole-punched, continuous, tag* or *ticket stock labels*. The diagrams below highlight some of the most popular label varieties used:

Die cuts with perforations between labels   *Butt cut labels with air eject slots*   *Hole punches and perforations*   *Notches and perforations*   *Horizontal and vertical face slits*

A printer's ability to operate with certain media types depends on the type of media sensors it contains. Label die cuts, black marks, notches or holes guide the printer in determining the top of the label, helping it work in tear-off mode or with cutter or peel options. Zebra printers come equipped with a variety of media sensors that enable the printer to gauge label length during the "media calibration" process.

Calibration is a process that a printer performs in order to gauge the length of the label material loaded within it. Sensors within the printer's media compartment—commonly located around the printhead—

detect either the white spaces between labels (inter-label gaps), or black marks and/or notches on the reverse side of the label stock that represent a label's actual face size (length). Printer calibration ensures that the data is aligned and prints correctly on the label stock.

Zebra printers can be configured to contain any one of the below sensor varieties:

Transmissive Media Sensor—This sensor is used to gauge label length for media with visible inter-label gaps, notches or pre-punched holes. Light from the sensor passes through the gaps in the label material's semi-transparent backing, enabling the printer to measure label length during calibration.

Reflective Media Sensor—A reflective sensor emits light that is reflected back to the sensor when it reaches a black mark appearing on the reverse side of the label stock. Such specialized media is commonly referred to as "black mark media."

Dual Media Sensors—Two sensors within the printer (one reflective and one transmissive) have the ability to detect *both* inter-label gaps and black marks.

Multi-functional Sensor—A single sensor within the printer has the ability to detect *both* inter-label gaps and black marks.

Application Surface

Application surface refers to the type of surface upon which the label will be applied. Surface features can be *flat, smooth, curved, rough, rigid, flexible, clean* or *contaminated* (dust, oil, powder, etc). Certain media types may be better suited to deal with certain application surfaces than others.
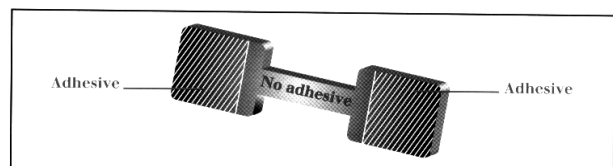
Adhesive

Generally speaking, there are two types of adhesives, *acrylic* and *rubberized*.

Rubberized adhesive is a pressure-sensitive adhesive based on natural or synthetic rubber. Rubber-based adhesives offer good general-purpose performance and may be used in a wide range of temperatures and on a wide variety of surfaces including plastic, glass, and metal. They can be used on most packaging materials, and provide excellent adhesion to corrugated materials. Most importantly, rubber based adhesives have **high initial tack**, meaning they stick immediately to a surface—making them particularly useful on curved or irregularly shaped surfaces.

Acrylic adhesive is a pressure-sensitive adhesive based on high-strength, acrylic polymers. Unlike rubber-based adhesives, acrylics **require time to set** (a minimum of 24 hours). Once they are set, they provide superior durability. Acrylics are extremely strong and resistant to environmental conditions, making them suitable for heavy-duty applications.

In addition, some labels come equipped with a *permanent* adhesive while others are *removable,* enabling them to be lifted off and re-adhered elsewhere. Adhesives are also a factor in *patterned* or *tamper-evident* labels*:*

▪ *Patterned labels* have adhesive only on portions of the label. Jewelry tags are a good example: The two ends of the jewelry tag have a permanent adhesive while the center has no adhesive so it will not stick to the jewelry item itself.

▪ *Tamper-evident labels* use a pigmented acrylic adhesive that leaves the word "VOID" behind on the product if the label is removed. Such labels are ideal for labeling physical assets where counterfeit detection and other security precautions are required.

Application Temperature

Application temperature refers to the minimum or maximum temperature present at the time of label application. Application temperature is important in that some adhesive materials are better suited to deal with extremes in heat and/or cold. A label that is not suitable to the application temperature may not adhere properly.

▪ ***Freezer-grade labels*** have special adhesives for use in extremely cold (-20ºF) environments. Freezer-grade materials can be applied at much lower temperatures than other adhesives.

Service Temperature

Service temperature differs from application temperature in that it refers to the temperature range that the label must withstand throughout its useful life. Items labeled by a food processor for storage in a refrigerated warehouse will have very different application and service temperatures. Zebra's *Supplies Selector Guide* is a helpful reference tool for gauging the application and service temperatures for Zebra's various media types.

Exposure

Exposure refers to the type of environmental conditions or stresses that the label or tag must withstand. Common stresses include *moisture/humidity, chemicals, abrasion, sunlight, heat,* and *cold.* Not using the right material to handle the environments that will be encountered can result in poor print quality, printer jams or fading.

Label Reading Method

The method of reading a label can differ depending on the application. The two most common methods of reading a bar code label are through the use of (1) *scanners* that interpret information when linked to an external computer database, and (2) *human readable* information that is visible to and easily read by the human eye. Human readable information runs the risk of being misread by a worker, potentially causing errors. Infrared scanners, although a reliable form of bar code data capture and transmission, operate best when used within certain distance ranges. When purchasing a scanner, it is important to make sure that it can perform within your required distance range. Scanner manufacturers specify the scanning range of their product on their specification sheets. In addition, be sure the scanner you select can read the type of barcode (linear or 2-D) used in your application.

Label Application Method

Labels can be applied by *hand* or by a *label applicator system.* While hand application requires no additional investment, it is not as efficient as an automated applicator system. Applicator systems are frequently pneumatically driven. A conveyor or pneumatic cylinder system aligns and positions the item toward a labeling station; then a pneumatically driven applicator arm applies a peeled label to the side of the product or carton. If your main concern is for speed, then you may wish to consider a label applicator system with a Zebra high performance print engine.

Environmentally Friendly Labels

For some applications, recyclable or other environmentally sound label material may be preferred. Linerless label stock is a good example of an environmentally friendly label material. As the name suggests, it uses no liner backing. Usually continuous (with no perforations), linerless label stock has a printable top side, while the reverse side carries a *light* adhesive, eliminating the need for a liner backing. Linerless label materials are particularly popular in Europe. Zebra offers linerless labels as well as printers that can handle the material.

Cost of Supplies

Printing supplies are consumables, so their cost is ongoing. If your application allows it, you can save money by using a direct thermal printer, which requires no ribbon. But as noted previously, without the slick cushion of the ribbon, direct thermal printheads wear down sooner than thermal transfer. Choosing cheaply made, poorer quality supplies will also negatively affect printhead life and print quality. Optimizing the supplies and the printer for your application, even if others are initially less expensive, will save you money in the long run.

ZEBRA APPLICATIONS AND SOLUTIONS

Zebra offers the world's broadest line of thermal printing solutions to satisfy a full range of industrial, commercial and mobile printing applications. Customers in industries including manufacturing and ERP, distribution and fulfillment, hospitality and travel, retail, healthcare, and government programs look to Zebra's reliable products to meet their automatic identification, personalization, and security requirements.

Zebra printing solutions include label, receipt and instant-issuance card printers, as well as printer supplies and software. Many label printers include Zebra's ZebraLink™ network connectivity and control solution. For more information on products in Zebra's comprehensive line or their applications, visit the Zebra Web site at http://www.zebra.com.

Bar Code, Label and Receipt Printers

Zebra's high-performance, industrial and commercial bar code label printers span applications from heavy-industrial, mission-critical, 24/7/365 applications to those requiring basic, general-purpose, intermittent labeling in light industrial or commercial environments. They range from tabletop to small desktop models. Zebra also offers heavy-duty print engines for print-and-apply applications, and RFID printers that encode "smart" labels with repeatedly updateable data using non-contact radio waves.

Mobile Printing Solutions

Zebra offers the broadest range of mobile printers on the market, along with a variety of wired and wireless connectivity options, to meet on-site, on-demand requirements. Rugged, mobile label printers can be found everywhere—mounted on forklifts to label cartons in a warehouse and in the retail store aisles for shelf labeling and price markdowns. Lightweight, mobile receipt printers, some of which include magnetic stripe and/or smart card readers, offer easy point-of-transaction processing and receipt printing. You'll find them on the go, outside hotels and at car rental agencies for convenient, curbside check-in. Zebra mobile printers are also used by law enforcement agencies for tracking evidence in the field or printing traffic tickets.

Plastic Card Printers and Encoders

Zebra instant-issuance plastic card printers and encoders can print bar codes—as well as digital photos, text, and security elements such as magnetic stripes, encrypted biometrics and holograms—for drivers' licenses, employee badges, access cards, and other identification and security cards.

Software Solutions

BAR-ONE® software turns Zebra printers into powerful tools for printing labels from all major computer platforms and ERP/WMS/MES systems without modifying your existing application—resulting in faster implementation, reduced development costs, and superior label output. The series includes BAR-ONE for R/3™ and BAR-ONE with JetForm Central™, certified by Baan and SAP.

Supplies

Zebra carries more than 1,000 combinations of Zebra-brand labels, ribbons, and tags—more than 300 of which are UL-recognized and CSA-accepted. Although they are made to the highest standards to work well with any printer, Genuine Zebra supplies are specially engineered to optimize the performance of Zebra printers, which means less wear and tear on printheads and reduced cost of maintenance. If you have a labeling application that cannot be solved using existing Zebra supplies products, Zebra's research specialists can design a customized labeling solution for you.

THE FUTURE OF BAR CODING

Ever since Zebra harnessed the power of the UPC bar code to help companies in other industries track inventory and record buying habits, Zebra has been equipping companies with reliable, technologically sophisticated products that help them run more efficiently and profitably. From yesterday's mechanical printers to today's sophisticated information management tools, Zebra continues to pioneer new technologies and apply emerging standards to on-demand printing. Today's most advanced Zebra printers offer wireless networking, RFID encoding, Bluetooth and 802.11b connectivity, all designed to make businesses more connected and employees more productive.

Want to Learn More?

Zebra Solutions Partners are trained to help you find the right Auto-ID system to improve your current processes, cut costs, and eliminate human errors. From our broad line of printers, supplies, and software, Zebra partners can provide you with a labeling or printing solution that is custom-tailored to your specific needs. For the name of a recommended Zebra Solutions Partner, call Zebra toll-free at (800) 423-0442 or visit our Web site at http://www.zebra.com.

You'll find a wide variety of specifying tools and bar code reference materials online to assist you in your planning. Through the Zebra Web site, you can access general bar code information, application ideas, industry solutions, product information, and technical help. At http://www.zipzebra.com, you can select and order in-stock supplies online for 24-hour delivery.

With our 30-plus years of experience in the bar code industry and our worldwide network of solutions partners, we hope that you will consider Zebra as a trusted resource in helping you find the right bar code printing solution to fit your needs.

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