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**On-Demand Printing Technologies**

**Executive Summary**

Some of the most popular choices for on-demand label printing are *dot matrix, ink jet, laser* and *thermal printing*

From a cost perspective, thermal printers tend to have a higher initial cost but a *lower long-term maintenance* and *operating cost* compared to standard office or document print technologies. This is due, in part, because thermal printers are considered a specialized print technology, accessible through a limited number of channels compared to that of popular office printing equipment which is readily available at any retail store.

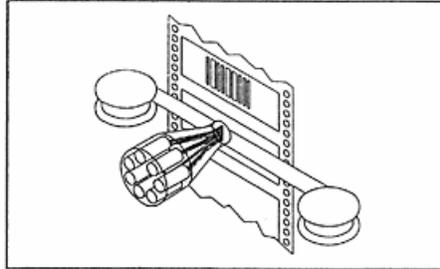
**In the long-term, the total cost of ownership of a thermal printer is lower due to (1) lower maintenance costs; (2) efficient label production with the decreased occurrence of label waste; and (3) steadily decreasing prices of ribbon and thermal based papers.** Lower long-term maintenance costs quickly offset one's initial investment cost enabling a rapid return on investment to be realized, especially when coupled with the increased efficiencies of bar coding automation on the whole.

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

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**Dot Matrix Printing**

Dot matrix print technology is one of the oldest techniques used for on-demand label printing. The typical dot matrix bar code printer is a modified line printer requiring pin feed paper stock. Solenoid driven needles impact 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.



Dot Matrix Printing

**Advantages**

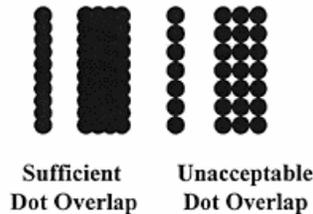
Dot matrix printers are readily accessible and inexpensive to purchase.

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 that can result in reduced overall cost for ribbons and the label material.

**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 barcode. The following example, compares *sufficient* dot overlap versus *unacceptable* dot overlap on a dot matrix printer used to print bar codes.



Continuous ribbon re-use on dot matrix printers requires continuous 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.

A dot matrix printed label is only as durable as a photocopy of paper. They commonly cannot produce chemical or water-resistant labels.

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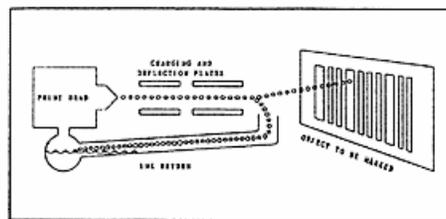
Printing of single, individualized labels results in significant *waste*. The design of the matrix printer's print carriage, sitting far below the media, also does not enable one to adequately maximize one's label space.

Dot matrix printing offers *NO graphic print* capability.

Print speed SLOW.

### **Ink Jet Printing**

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 frequently used for coding products and cartons with human readable data and lot codes at very high speed and for case coding of cartons with bar codes.



Deflection Ink Jet

### **Advantages**

Common direct marking process on a product or carton that involves only one step compared to label printing which requires two steps: printing a bar code label and adhering it to the product.

A favorite on high-speed production lines due to its "mark-on-the-fly" capability. "Mark-on-the-fly" being an affectionate term to describe this print process within the industry.

Used primarily for industrial use amongst large conglomerate organizations due to the affordability issue and high product volumes.

### **Limitations**

Costly system installation designed for high volume of product labeling – not for individual or small batch label bar code printing.

Routine maintenance and supervision required to ensure consistent print quality and to prevent ink jet "clogging".

Limited dot placement accuracy and bar code density due to ink splatters and product being in continual motion.

Material to print on is restricted due to the advent of ink bleed on some materials.

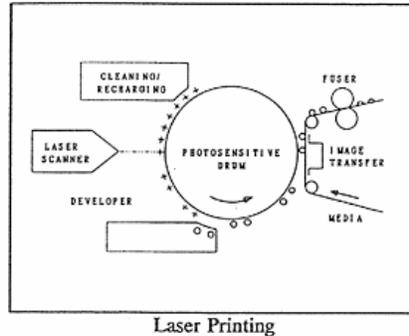
Poor contrast of bar codes on corrugated box materials due to their dark backgrounds.

Properly matched scanning devices must be chosen to ensure bar code reliability.

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**Laser Printing**

The laser printer works much like a photocopier projecting 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 bar code labeled documents on plain paper.

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 is also quite high on laser printers resulting in a scannable code at virtually any wavelength using an infrared scanner.

**Limitations**

Laser printers are not well suited for industrial labeling applications or individual product labeling applications. Here, they prove inadequate and wasteful as it is impossible to produce single or small labels. (A minimum of a ½ 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 labeling adhesives must be carefully selected to ensure stability under the heat and pressure of the fuser. Otherwise, it may extrude onto the printer mechanism, where it will capture stray toner or "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 sheet form for the laser printer to be able to print on.

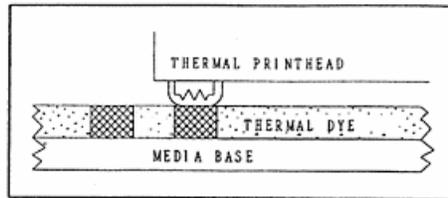
A laser printed label is only as durable as a photocopy of paper. They commonly cannot produce chemical or water-resistant labels with the image longevity of a thermal printer.

Cost of laser toner cartridges for bar code printing is significant and can be costly. A 5% black density, for example, is commonly required for standard word processing versus a 15-30% black density for bar code printing. **Bar code printing on a laser, therefore, is 6 TIMES more expensive than standard word processing printing!**

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**Direct Thermal Printing**

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



Direct Thermal Printing

**Advantages**

Direct thermal printing is an excellent choice for many bar code applications because of the consistent, sharp edge image print quality that they can generate.

Direct thermal is ideal for applications with a short shelf life requirement – meaning the label is not required to last very long. Many packaging companies utilize direct thermal technology since the address and package tracking labels only need to last long enough to reach their destination which is typically accomplished in a few days.

Direct thermal printers provide simplicity and environmental economy with re-cyclable materials available.

Direct thermal printers are simple to operate compared to most other print technologies – no ribbon or toners to replenish or monitor.

Low, long-term maintenance cost compared to comparable technologies.

Enables batch or single label print capability with virtually no waste.

Direct thermal is durable compared to other comparable print technologies.

Office and/or limited industrial application usage, though more limited in application than thermal transfer due to its shorter image longevity.

**Limitations**

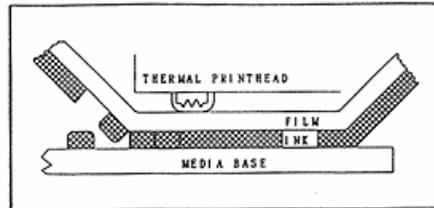
Direct thermal printing is extremely sensitive to environmental conditions – e.g. heat and light (fluorescent and/or direct sunlight).

Direct thermal paper remains chemically active after printing. Because of this, all thermal paper materials used – labels, tags or ticket stock – are top coated to resist UV light exposure, chemicals and minimal abrasion.

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**Thermal Transfer Printing**

Thermal transfer printers use the same basic technology as direct thermal printers, but with the elimination of chemically-coated media material in favor of a non-sensitized face stock and a special inked ribbon. A durable, polyester ribbon film coated with a dry thermal transfer ink is placed between the thermal printhead and label. The thermal printhead is used to transcribe 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



Thermal Transfer Printing

**Advantages**

High contrast, crisp image bar code print quality with a durable, long-life and archival image stability.

Ideal for batch or individual label print capability – with virtually no waste.

Low, long-term maintenance cost compared to comparable technologies.

Maximum readability and IR scannability.

High contrast text, graphic and bar code print capability.

Durable for operation in office or industrial applications.

Capable of printing on an unlimited variety of media stock – except multi-form.

**Limitations**

Single pass thermal transfer ribbon can be wasteful if little is printed on it.

Ink transfer ribbon is a poor candidate for re-cycling

To obtain optimum print quality in thermal transfer, 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.

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**When to Select Thermal Printing Technology**

For most engineers involved in bar code system automation deciding where a bar code printer is appropriate is a straightforward task. But specifically, when should a thermal printer be considered? Direct thermal or thermal transfer printers can be specified for use in applications when any of the following criteria are specified:

**A point-of-application system is required**

*Point-of-application* refers to the requirement for a label to be generated at the exact time and location where it is to be applied to the product in question. In a manufacturing process, point-of-application labels are frequently required to label the product for product identification purposes or to label the product packaging in preparation for shipment.

**Individual and / or batch printing of labels with variable data is frequently produced**

Thermal printers are ideal for applications that require individual or batch labels that contain variable data bits or fields that change frequently and cannot be serviced by an outside printing agency. 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.

**Alternating label widths and/or length materials are frequently being used**

Thermal printers are ideal for labeling applications with varying label widths and/or lengths because they adapt to varying size labels easily and promote label production without waste. Comparable available print technologies, such as laser or dot matrix, cannot make such claims because of the waste factor and the limited availability of label materials and/or sizes in sheet or pin feed format.

**Graphics printing and/or unlimited adjustable (scalable) text font sizes are desired**

Thermal printers not only promote user-flexibility to print individual or batch labels on alternating size media. It is the only print technology whose software permits you to incorporate and print virtually any custom graphic or international symbol, be it your corporate logo or other related universal graphic icons such as *Fragile*, *UL*, or *Flammable* into the label design. Text fonts are also *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 point sizes. A printer's capacity to operate such text fonts or to download graphic formats is dependent on the amount of memory that the printer has to adequately store and process such information. The more memory a printer has, the more complex fonts operations it can perform and process more quickly and efficiently.

**High density bar codes are needed**

Thermal printing is ideal where high density (crisp, high definition / contrast) bar codes are required. Thermal print bar codes also have one of the highest scanner read rates compared to comparable print technologies.

**Clean, quiet, compact printer operation with low maintenance and operating cost is preferred**

Thermal printers are highly compact promoting clean, quiet operation compared to comparable print technologies, such as dot matrix or ink jet printing, for example. Thermal printers come in two basic varieties – *tabletop* and *desktop*. Tabletop thermal printers are typically bigger than desktop thermal printers in size 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 longer without frequent interruptions to change or replace media that can effect one's overall productivity, dependent on the number of printed labels required).

From a space consumption perspective, tabletop printers typically take-up the surface area of a typical office laser printer, whereas a desktop printer utilizes about the surface area of a typical office phone or standard mouse pad. This surface area or space consumption comparison is typically referred to as the printer's *footprint* within the bar code industry.

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