DIRECT THERMAL LABELS & TAGS

Thermal and thermal transfer printing began their rapid growth in the mid 1980s, driven by the implementation of automatic identification systems utilizing bar code. These systems make possible the fast and reliable collection and transfer of information. As a result, this is the preferred method for on-demand printing requirements, given its relative low cost and reliable process.

Both direct thermal and thermal transfer printing technologies use heat to create an image. The printers employed in both technologies use the same type print head, with the media used determining the process employed. In fact, most thermal transfer printers can be converted to direct thermal printers by disabling the ribbon mechanism.

PRINTER TECHNOLOGY

The print head is the key to the process. They are solid state and designed to operate in warehousing and manufacturing environments. Print heads are stationary and the media advances past it. They contain a line of tiny, single controlled elements (hot dots), numbering 200 to 400 per inch arrayed across the face of a ceramic carrier plate. The number of elements in a print head determines print resolution (DPI), with most being 203, 304, and 400 DPI.

The elements in the print head are square whereas laser and ion deposition utilize round dots. This is a key difference that allows thermal and thermal transfer to print straight edges. This allows these printers to print higher density bar codes. Because of the difference in dot shape, direct thermal and thermal transfer technology provides higher quality bar codes than laser or ion deposition technologies, despite having similar DPI resolution.

As the material passes under the print head, the row of heated elements are turned on and off by impulses from the computer. The image is created one row at a time as the material advances.

DIRECT THERMAL PRINTING PROCESS

In direct thermal printing, the print head comes in direct contact with the face of the media. Thermal media has a heat sensitive coating that reacts to the heated elements in the print head resulting in an image. Print quality is very good, but dependent upon the quality of the coating sensitivity on the media being imaged and the heat setting of the print head.

Some older infra-red scanners cannot read standard direct thermal media consistently and therefore require special infra-red or near infra-red thermal media which are more expensive.

Direct thermal applications are best suited for indoor applications where temperatures are below 140 degrees F. Because the image is heat sensitive, light sensitive and chemical sensitive, prolonged exposure to sunlight or UV light may cause the image to fade.

SUBSTRATES

Direct thermal substrates include synthetic and paper label, tag, and paper stocks. Direct thermal substrates are more expensive than thermal transfer, but do not require the ribbon. Direct thermal substrates have a pre-applied heat sensitive coating. Print color is largely limited to black. Coating sensitivity is controllable and varies based upon the application requirement.

Thermal coatings and images are sensitive to heat, UV light, and chemicals. Thermal imaged documents will remain legible 5 to 7 years under normal storage conditions. Five years is considered the traditional standard, however substrate suppliers acknowledge 7 years being reasonable under normal storage conditions. Normal storage conditions are defined as normal filing conditions…a closed filing cabinet in an environment below 77F with 45-65% relative humidity. Because thermal coating is sensitive to chemicals, thermal documents should not be stored next to incompatible chemical-based or coated materials including plastic, vinyl, hand lotion, oil, grease, alcohol-based products, carbonless paper and carbon paper.

Almost all direct thermal label and tag substrates include a protective overcoat on top of the thermal coating. This protects the coating and the imaged text and graphics from scuffing and other forms of moderate abrasion. Non top-coated substrates are available upon special request; otherwise most manufacturers will be utilizing substrates with a protective overcoat. Stocks without the protective overcoat are less expensive, but will definitely scratch easily, altering the imaged text and bar code. This will typically render the bar code unreadable.

Most printers operate with a medium sensitivity coated substrate. High sensitivity coating is required for printers with high-speed capability or printers with low voltage capability (lower heat generating pins), typically small handheld printers.

Thermal, medium sensitivity: A top coated medium sensitivity thermal coating for use in standard speed thermal printers. This coating is used in a variety of industrial and retail bar code applications. Optional stocks are available with heat resistance characteristics where applications are exposed to heat lamps and food warming systems. Medium sensitivity coating is available in paper, tag, and film stocks. Coating is available in low and high sensitivity levels as well.

Thermal, high sensitivity: For use in high-speed thermal printers. High sensitivity grades work well in low voltage print heads (minimizing print head wear). Available in paper and tag stock.

Thermal IR: A smooth, white facestock with high sensitivity IR scannable top coating, capable of being scanned with an infrared light source. Excellent resistance to direct water exposure. Superior resistance to heat and humidity.

Thermal Red: A smooth red fluorescent coated paper with a medium sensitivity thermal coating.

Thermal NIR: A bright white paper with a medium sensitivity thermal coating designed for used with scanners in the 675 nm light range. Infra red scannable coating is also available.

Thermal OL: A medium sensitivity thermal paper over-laminated to provide exceptional resistance to chemicals, solvents, abrasion and other harsh environmental conditions.

PRINT QUALITY: Image quality is a function of the substrate coating sensitivity (low, medium, high), the heat (voltage) setting of the printer, speed of the printer, condition of the substrate (old, pre-exposed to UV light, type of preprinted ink, etc.), and print head condition (dirty, worn, etc.). While the process is very simple, problems occasionally occur due. The vast majority of problems are due to the incorrect use of the products…usually because the substrate, heat, and speed settings have not been properly matched. As a result, the printed image does not satisfy the requirements of the end user.

Print quality depends on several factors:
1. The type of printer. There are two primary types of printers; flat head and near edge. Near-edge printers process thick and/or stiff substrates better.
2. Print head resolution. The higher the resolution, the better the print quality.
3. Printer adjustments. Heat, speed, and impression pressure controls will impact the quality of the printed image.
4. Substrate characteristics. The substrate must have the correct coating sensitivity for the printer and/or application.
5. The image being printed. Images with curved edges, such as type and artwork, are difficult to print because of the square dot shape. Other images, such as ladder orientated bar codes or heavy solids can only be printed adequately at slow speeds.
6. Printing environment. Print quality can deteriorate if the substrate is subjected to certain environmental conditions such as UV light or heat, as well as physical conditions such as scratching, abrasion, or exposure to chemicals. The optimal printing environment is between 41-77 degrees F and between 45-65% humidity.

ADVANTAGES:
- Thermal printers are relatively inexpensive and have a very simple mechanical design that is highly reliable.
- The simplicity of design results in a minimal size.
- Furthermore, the simplicity and size require little power and no ribbons.
- This makes it ideal for applications requiring portability.
- Excellent print quality for straight edges and lines.
- No down time is required to change consumables like ribbons or toner.
- Very quiet.
- Excellent for batch and on-demand printing.
- Bar codes will not smear or rub off.
- Prints high-density (narrow bar) bar codes.
- Clean handling. User not exposed to soiling from ribbon or toner.

DISADVANTAGES:
- Images can/will fade over time. Thermal substrates will react to UV light and/or high temperature exposure.
- Thermal substrates are sensitive to chemicals. Stock will turn black if exposed to chemicals (ironically a potential security feature).
- Poor print quality for curved edges.
- Special substrates (thermal coated) are required. They are more expensive.

- Near infrared and infrared scanning requirements require a special, even more expensive thermal stock, with few options.
- Thermal substrates have a shorter shelf life.
- Modest scratch resistance.
- Few options for chemical resistance.
- Print head replacement is more frequent with direct thermal versus thermal transfer. Print heads are costly. Unlike thermal transfer, there is no barrier between the print head and the substrate. As a result, there is wear upon the print head from the coating on the substrate.

APPLICATIONS

Because thermal printers are so reliable and do not require toner, ink, or ribbon replacement, they are very popular in applications where cleanliness, unmonitored operations, and portability are important. Medical applications, kiosk applications, gaming applications, mobile/portable/handheld printer applications, point-of-sale applications, and measuring/analyzing applications are among those applications in which thermal printers are desirable.

DESIGN CONSIDERATIONS

- **Print Registration:** In order to register the start of printing to the top of the label or tag, the printer must be able to identify the start of the label or tag. A sensor that scans the substrate for a change in opacity typically determines this identification. This difference in opacity can be achieved in a number of ways.
    - In the case of die cut labels, the sensor will sense the space between the labels as having lower opacity and hence the end beginning of labels.
    - In the case of tags a dark stripe is printed across the back of the tag, typically near the between set perf. The sensor will sense the higher opacity across the area with the stripe and hence the end beginning of the tags.
    - With some printers, the sensor requires a clear, open space. In such cases, the label or tag stock will need a sensing hole die cut between sets or an edge notch between sets to create this clear path.
- **Special considerations for portable printers:** Portable printers offer flexibility in workflow. However, batteries are usually used for powering them. Most portable printers will automatically slowdown as the battery charge depletes. There are some design issues that can maximize power utilization:
    - **Matching Substrates to the Printer and/or Application:** Make sure that the substrate of choice will work both in the printer (speed and/or voltage considerations) as well as the application (IR or near IR requirement, environmental issues like chemical, UV, or heat exposure). Correct substrate selection is critical for generating clean images and minimizing wear as well as for avoiding residue build-up, paper sticking, and print head wear. Since both the base paper and thermal coating interact with the print head, the proper relationship between the substrate and the print head is essential for best performance
    - **Text and Bar Code Orientation:** Design text and bar codes in the horizontal orientation instead of the vertical orientation. Printers will print slower with text and bar codes in the vertical orientation. Also, bar codes printed in the horizontal orientation tend to scan better than bar codes printed in the vertical orientation.

    - **Large Solid Print Areas:** Avoid printing large solid areas. If it's an absolute requirement, design the solid print area to print vertically rather than horizontally (perpendicular to the print head instead of parallel to the print head). The key is to avoid any print design that

requires all the print head elements to be used at the same time. This creates significant stress on the print head (and the battery in portable units).

- **Thermal Inks:** Heat resistant inks must be used to prevent the thermal print head elements from melting ink off the substrate and onto the print head surface. Failure to do so will damage or destroy the print head. Metalized inks are not recommended because metal is an excellent heat conductor; it absorbs the heat of the print head elements before the image is successfully developed on the substrate surface.

- **Substrate Quantity per Roll or per Flat Pack:** Standard printers will accept rolls with outside diameters up to 8 inches. Print-and-apply printers can frequently accept rolls with larger outside diameters. Portable printers typically require smaller cores (1" versus 3") and can accept rolls with 2-3" outside diameters.
  Some standard printers and print-and-apply printers can accept flat packs. The quantity per flat-pack may be determined by whether the pack is loaded inside the printer casing or is fed from outside the printer casing.

- **Thermal Label and Tag Shelf Life:** It is recommended that thermal labels and tags be used within one year of purchase. Storage conditions for unused inventory should be the same as storage conditions for used archived labels and tags: an environment below 77F with relative humidity between 45-65%. Furthermore, unused media should be protected from light exposure (i.e. keep in a closed carton).

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