DOCUMENT SECURITY ISSUES

Part of a Series of Datacard Group White Papers for the Secure Document Issuer

ID DOCUMENTS – A BUILDING BLOCK APPROACH FOR SECURE IDS

Overview

This paper is intended as a reference for government officials considering technologies available for issuing secure IDs. There are three major components of this decision:

- **Card body or card substrate material**
- **Print or personalization technologies**
- **Laminate or topcoat material**

All three elements must be compatible for a successful ID document program. Each component impacts the cost, durability and security of the ID, and there are many trade-offs involved in a decision on the appropriate combination. There is no "best" method, so the technology choices should be carefully evaluated against program requirements, and rigorously tested using the components selected.

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SECURE ID AND CARD PERSONALIZATION SOLUTIONS

Card Materials - Substrates

1. **PVC** (Polyvinyl chloride) is the most widely used material for plastic cards, and has been used for photo IDs for more than 10 years. Low in cost, the smooth surface of photo quality PVC material accepts dyes for high quality ID image printing and is compatible with most laminate materials. In sheet form PVC can be offset printed with sophisticated designs and security features. Although there are a wide quality range of PVC materials, durability is limited for applications with high usage. Material can be printed as pre-cut cards or sheet material (on large digital presses). Cards are typically constructed with three or four layers and laminated in a single piece. Cards can be easily configured with RFID, IC and contactless technology. PVC is generally the lowest cost of the materials used for IDs, and is primarily used for IDs with 1 – 3 year durability requirements.

2. **PET** (Polyethylene terephthalate) is a polyester material that was used for many years for the pouch-laminate style of IDs. It is a crystalline plastic and has higher heat resistance than PVC. Durable and resistant to moisture and chemical attack, the material is typically used as an outer laminate for PVC, composite and Teslin cards. PET is more expensive than PVC, so is generally used as part of a multi-part card construction. PETG is a modified form of PET which can be printed and laminated easily like PVC. However, PETG is not as durable as PET. Durability of PETG is somewhat comparable to that of PVC.

3. **Composite Cards** typically combine layers of PVC and PET. Developed initially for the college and university ID market, card constructions combine varying amounts of each material to meet a range of durability requirements and price points. The outer layer of the construction is PVC to facilitate digital printing, and the inner core is PET for greater flexibility and durability. It has the same offset printing and card construction characteristics as PVC, and can be easily configured with RFID, IC and contactless technology. Manufacturers continue to develop new composite constructions (e.g. PVC/PET/PC) to add specific performance characteristics. Composite cards are often used for government IDs requiring longer life.

4. **Teslin®** is a synthetic porous material produced by PPG Industries. It is receptive to conventional offset printing used for high security designs. .In sheet form, it can be printed using standard color electrophotographic (laser) printers or inkjet printers. Because the surface is not smooth like PVC it cannot be directly printed with dye diffusion printers. Teslin material is highly flexible, and resistant to most chemical and UV degradation. ID cards made with Teslin materials are typically constructed with multiple layers: a front and back printed side, and front and back lamination. Laminates are typically PET and require specialized adhesives for bonding, making them susceptible to deliberate delamination. Cards with a Teslin core are typically used for government IDs requiring longer life.

5. **PC** (Polycarbonate) is an extremely durable thermoplastic polymer with high temperature resistance and impact resistance. Used in items like CDs and DVDs, it is receptive to offset security printing. PC is not as receptive to variable printing such as dye diffusion or resin transfer. When constructed with a very thin transparent laser-receptive layer, PC cards can be laser engraved with very high definition graphics. Cards can be assembled with RFID, IC and contactless technology. PC is more difficult to manufacture, and is more expensive to produce than PVC or composite cards. PC cards are primarily used with laser technology to produce black images/text. PC or PC composite cards are typically used for the longest life and/or highest security IDs.

6. **ABS** (Acrylonitrile butadiene styrene) is generally used for very low-cost stored value phone card (memory card) applications. The material is injection molded and is not compatible with ID card printing technology. It is receptive to screen printing and simple offset printing, but because the surface is not as smooth as the other materials listed security offset printing is not practical. It is also not compatible with dye diffusion or color electrophotographic printing.

Table 1. Card Substrate Comparison

	PVC	PET	Composite	Teslin	PC	ABS
Heat Stability (Warpage)	3	1	2	1	1	3
Flex Resistance	3	1	2	1	1	3
UV Resistance	3	2	2	1	2	3
Cost	1	2	2	2	3	1
Compatible with Contact IC	1	1	1	3	1	1
Compatible with Contactless IC	1	2	1	2	2	3
Delamination	2	2	2	2	1	-
Laser Engravability	2	3	2	3	1	3

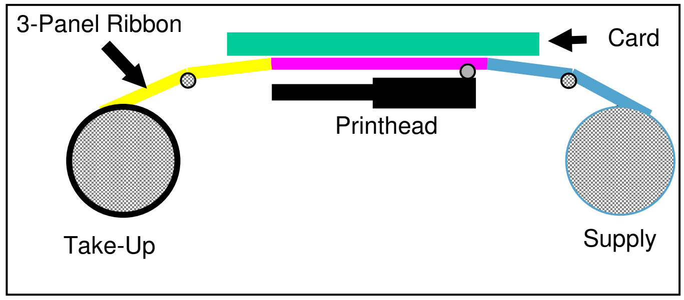
1 = Best 2 = Better 3 = Good

Print Technologies

1. **Dye Sublimation** (sometimes called dye diffusion thermal transfer – or D2T2) uses heat to transfer dyes to a substrate. Used for high quality color printing, the process creates continuous tone colors by varying the amount of heat applied. Typically a 3- or 4-color ribbon (cyan, magenta, yellow and black) is passed under a thermal printhead and heat is applied to deposit dye. Ribbon dyes can be applied:
   a. **Direct** - printed directly to a card surface; or,

b. **Retransfer -** printed to the backside of a clear retransfer ribbon which is then fused to the card surface. Frequently used to personalize smart cards which may have irregular surfaces.

Figure 1. Dye Sublimation - direct printing



An advantage of the dye sublimation process is the extensive range of colors that can be created. Slight variations in heat create different shades of the same color and the transparent dyes can be applied over one another, creating solid color gradients. Technologies such as inkjet or color electrophotographic printing rely on dithered images where solid color dots are printed closely together creating a visual appearance of a solid color. The typical 300 dpi printhead then can achieve image quality superior to a 300 dpi resolution from dithered images. There are a wide range of desktop printers and several central issuance printers using direct and retransfer technologies. These printers include in-line personalization of magnetic stripes, contactless or contact chips, RFID, etc.

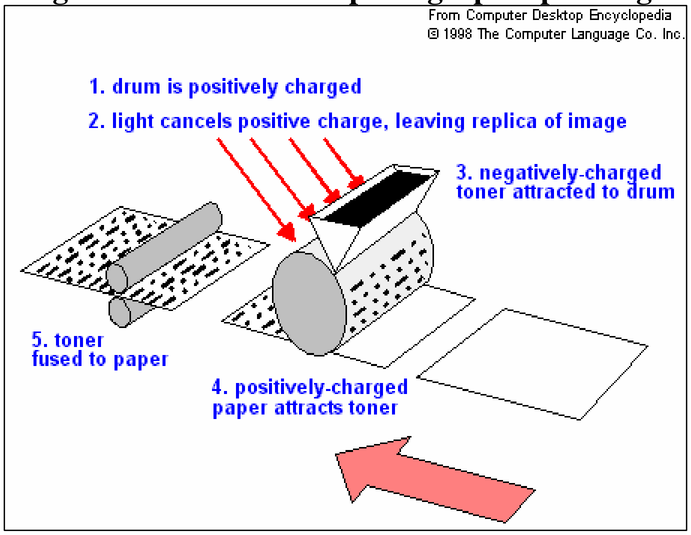
A disadvantage of this technology is the supply cost for the multi-panel ribbon. Another limitation is that the dyes need to be protected from degradation that may result from chemical or ultraviolet radiation attack.

2. **Resin or Pigment Transfer** is another application of thermal transfer printing using heat to deposit resin or pigment on a substrate. Thermally applied resins are more stable than dyes and are much more resistant to fading. Resins can be applied:
   a. **Direct** - printed in monochrome directly to a card surface; or,
   b. **Retransfer -** using resins on a 3- or 4-panel ribbon printed to the backside of a clear retransfer ribbon which is then fused to the card surface. Specially formulated retransfer ribbons are more receptive to resins than PVC, and can be printed at higher dot resolution. Retransfer can be used to personalize smart cards which may have irregular surfaces.

The Datacard® Artista® VHD retransfer color printing module enables high resolution 600 dpi color printing for superior image quality as well as the flexibility to print 1200 dpi variable microprinting to create microprint fonts and images. This system can also be configured for in-line personalization of magnetic stripes, contact or contactless chips, RFID, etc. As with dye sublimation, supply costs are higher than for other non-thermally applied images. Direct print applications are currently limited to monochrome to print text and logos, and not for photo imaging.

3. **Color Electrophotographic** printers use lasers or LEDs to transfer 3-color images to an intermediate surface (drum or belt) where the toner is then applied to the media. A typical color "laser printer" uses 3 colored toners – usually cyan, yellow and magenta. Advantages of this technology are its' high speed and low consumables cost. Designed initially for cut-sheet paper, they support a limited range of media or card substrates, and cannot print directly to PVC, PET, PC or Composites. Paper and Teslin are the most commonly used substrates.

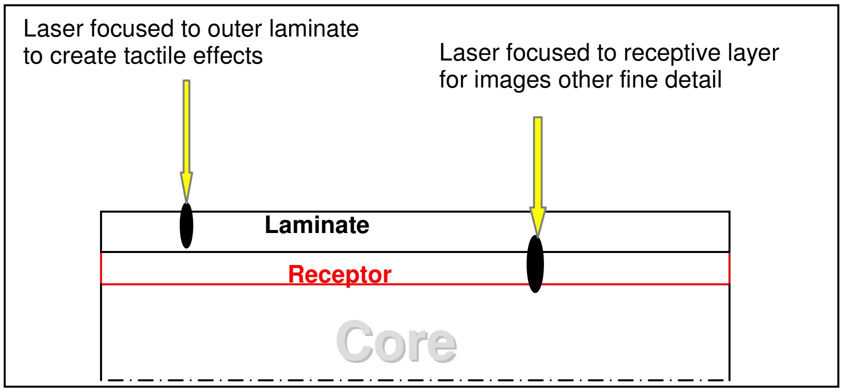
Figure 2. Color Electrophotographic printing



Producing an ID card starting with cut-sheet size media requires multiple steps: printing, assembling (front and back), lamination and die-cutting. Additional processes are required for other card personalization functions such as magnetic or smart chip encoding. Half-tone printing for color limits the image quality compared to dye diffusion or laser engraving.

4. **Laser Engraving** When polycarbonate molecules are hit by a focused laser beam they change to tiny carbon bubbles. These form a black color, and permanently alter the substrate. By directing a laser beam at an opaque polycarbonate material laminated under the surface of the card, it is possible to print or "engrave" high resolution images or typeface below the top surface. Even microfeatures can be introduced. Varying the amount of laser energy enables true gray-scale printing which produces photo-quality black and white images. The resulting text or image does not fade and is not subject to deterioration from UV light, moisture or surface abrasion.

Figure 3. Laser engraving – Card cross section view



A laser beam can also be focused at the outer laminate of the card with enough energy to disturb the card surface, creating a tactile effect. Unlike the other printing technologies

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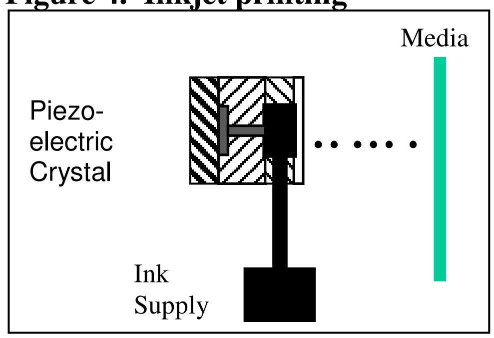
described, there is no ongoing supply items (ribbons, toners, foils or overlay materials) required.

There are a limited number of manufacturers of laser engraving personalization systems. These systems can be configured with in-line personalization of magnetic stripes, contactless or contact chips, RFID, etc.

The equipment required to produce laser engraved cards or documents is more expensive and technically sophisticated than the other print methods described, making it very difficult to be procured for unauthorized use. This technology has been used in Europe for more than a decade for high security documents.

5. **Inkjet** printers create an image by forcing droplets of liquid ink under pressure from a printhead. The printhead may have one or more nozzles, and use one of three main technologies: thermal, piezoelectric, and continuous. Current inkjet technology can produce near photographic quality with half-tone shades on specially coated paper.

Figure 4. Inkjet printing



A major advantage is the low cost supply "ink on demand" feature, yielding lower cost per document than the dye, resin or toner printers.

Current inkjet inks are not compatible with plastics such as PVC, PET or PC, and are easily removed after printing. Similar to electrophotographic printing, inkjet printing on Teslin cut-sheet size media requires multiple steps: printing, assembling (front and back), lamination and die-cutting. Additional processes are required for other card personalization functions such as magnetic or smart chip encoding.

Table 2. Print Technology Comparison

	Dye Sublimation		Resin Transfer				
	Direct	Retransfer	Direct	Retransfer	Inkjet	Laser Engraving	Electro-photography
Print Resolution	2	2	2	1	1	1	2
Image Quality	1	1	2	1	2	1	2
Consumables Cost	3	3	2	3	2	1	2
Laminate Adhesion	1	1	1	1	2	1	2
Speed	2	2	2	2	3	3	1
Complexity of Technology	1	2	2	2	1	3	3
Security	3	3	3	2	3	1	3

1 = Best 2 = Better 3 = Good

Laminate or Topcoat Materials

1. **Thin Film Topcoats** Color thermal transfer ribbons (dye and resin types) typically include a clear topcoat panel which is applied to the entire surface of the card once the color printing is complete. The topcoats are designed to prevent dye migration and provide only limited abrasion and chemical resistance. Topcoats are commonly used on corporate ID cards where the card is primarily for visual identification. Topcoats can be intentionally removed allowing alteration and/or replacement of printed information.

   Thin film security topcoats incorporating optically variable features (e.g. holograms or specialized inks) are also used to provide a level of counterfeit and tamper resistance. The films are only several microns thick and cannot be removed intact, providing a high level of tamper evidence. Combined with a clear topcoat these two layers offer slightly better chemical and abrasion resistance, but can still be removed. This type of security topcoat is used on many IDs where security threats from tampering or alteration are not significant. They are also used on ID documents such as passports where the surface is not subjected to higher levels of abrasion common to ID cards.

2. **UV-Cured Topcoats** Ultra-violet cured topcoats are available on all Datacard® central issuance systems and provide a higher level of abrasion and chemical resistance than thin topcoats. The material is applied during personalization and then cured with a UV source. It offers a moderate level of protection for thermally printed images and text. They are commonly used in financial or loyalty cards, but are generally not recommended for ID applications.

3. **Polyester Laminates** Polyester laminates are used in roll form and applied as "patches" to the surface of a card, or in sheet form to a cut-sheet substrate. In both cases the material is laminated with heat and pressure to the surface of the card. Applications for ID documents typically use laminates ranging from 0.0005 – 0.001" (one-half to 1 mil). These laminates are best for abrasion and chemical resistance, and can incorporate UV blockers to protect against fading. They are extremely flexible, and can significantly extend the useful life of many types of ID documents.

   A wide range of security features can be incorporated into the thicker laminates, including optically variable features, security printing, or serial numbers. These laminates are used on many secure government IDs providing a high level of counterfeit and tampering deterrence.

   The strongest level of lamination occurs when combining identical or chemically-linked materials where the laminate and substrate are fused under heat and pressure. Laminating polyester materials to other types of substrates requires specialized adhesives. Because the laminate material is thicker, it may be easier to remove intact leaving the original card or document vulnerable to tampering.

Table 3. Topcoat and Laminate Comparison

	Thin Topcoat (Edge-to-Edge)	UV-Cured Topcoat	Polyester Patch
Abrasion Resistance	3	2	1
Chemical Resistance	3	2	1
Delamination Resistance	1	1	3
Permeability (Resistance to Cracking)	3	2	1
Appearance	2	2	3
Ability to Incorporate Security Feature	2	3	1
Cost	1	2	3

1 = Best   2 = Better   3 = Good

Putting it all together

Defining a secure ID document should be viewed with a systems approach, evaluating how each component interacts or complements the others. Selecting what may be perceived as the "best" of each component category will not necessarily provide the best outcome. Factors such as durability, ability to incorporate security features, price (initial investment and ongoing supplies and maintenance cost), scalability, upgradeability, and availability on the open market should be included in determining which components best fit an application. As noted earlier, there will be trade-offs with each choice.

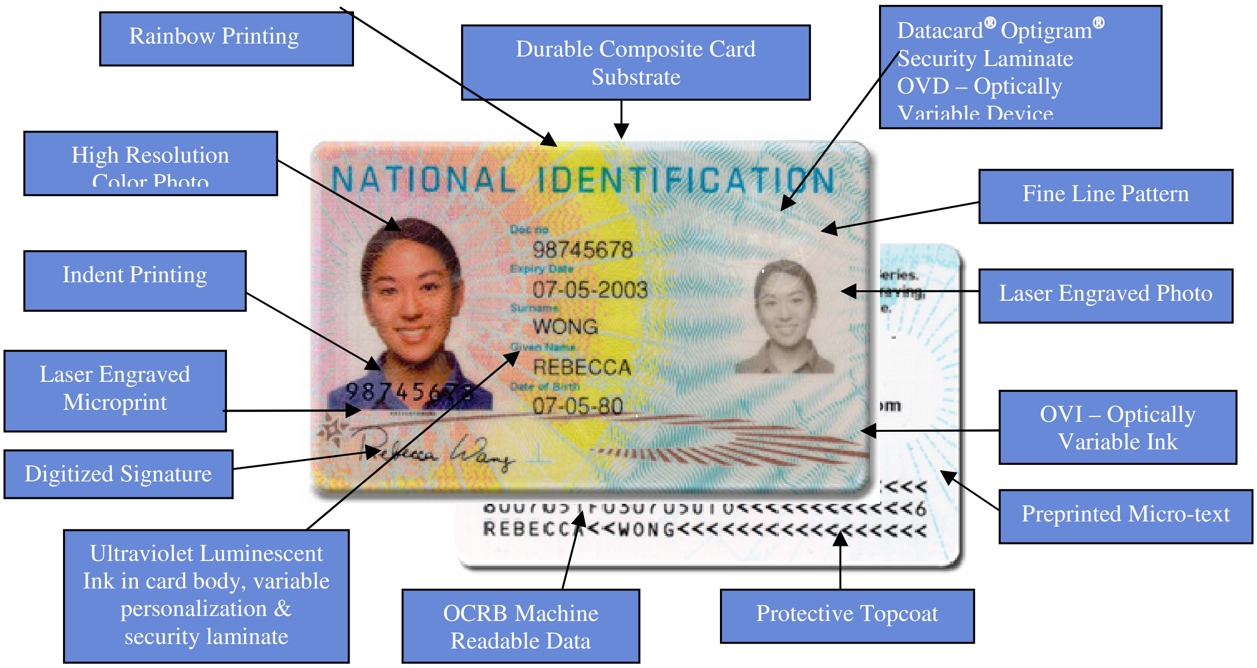
Testing the "system" before making a selection and on an ongoing basis will strengthen its reliability and security. Key characteristics should be tested – such as machine readability, durability, resistance to tampering or alteration, etc.

Some general guidelines to improve the outcome of this process include;

1. Start with a secure and durable card substrate.
2. Add variable personalization technologies (printing, encoding, etc.) that are compatible with the substrate.
3. Add tamper-resistant and tamper-evident features that physically alter the substrate or that will leave permanent visual evidence of tampering attempts.
4. Include technologies for machine-readable data that add security.
5. Monitor changes in any of the critical materials once the program has started, and thoroughly test any recommended material changes.

Shown below is an example of a high security card produced using a composite card, laser engraving, high resolution resin retransfer printing and a high security 1 mil laminate. The card design includes pre-printed security patterns to increase protection against counterfeiting.

Figure 4. High Security ID Example



Recommended Readings:

1. "Personal Identification — AAMVA International Specification — DL/ID Card Design" www.aamva.org
2. ANSI/INCITS 322:2002 - Card Durability Test Methods   www.incits.org or webstore.ansi.org
3. International Card Manufacturer's Association www.icma.com
4. The Real ID Act, Secure ID Documents And Related Security Processes (White Paper) Document Security Alliance   www.documentsecurityalliance.com
5. Card Security and Durability Supplies for Printed Cards www.datacard.com (White Paper)

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