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PHOTOCOPIES

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AUSTRALIAN ARCHIVES

Photocopying and Laser Printing Processes – Their Stability and Permanence

Photocopying and laser printing techniques are commonly used to produce a wide range of records and publications for long term storage in Commonwealth agencies. The longevity and durability of records produced by this process are of concern to government agencies which require them to be permanent and durable records and to archivists and librarians who must retain these documents for posterity.

This paper reviews common electrophotographic processes and provides practical advice on measures to improve the durability and long term stability of photocopied and laser printed materials.

Photocopying Processes

Below is an overview of the main copying processes in current use and the steps involved in producing different types of electrostatic images.

Xerography

The most common contemporary photocopying process uses the basic principles of static electricity to create an image on a sensitised surface, which is then electrostatically transferred to paper. The xerography process may use dry or liquid toners and is similar for both. Below are the five basic steps in this process:

- **Charging step** - a strong electrical charge is uniformly distributed onto the surface of a photosensitive plate known as a photoreceptor.
- **Exposure step** - the image to be copied is optically projected onto the sensitised surface resulting in a pattern of surface charge called the latent electrostatic image.
- **Development step** - toner of the opposite sign is brought into contact with the charged photoreceptor. The toner particles are attracted to the charged areas resulting in a physical image that consists of electrostatically held toner particles.
- **Transfer step** - a sheet of paper is brought into contact with the photoreceptor surface. An appropriate charge applied to the back side of the

paper attracts the toner image to it. The paper leaves the photoreceptor with the toner clinging to it electrostatically.

- **Fixing step** - dry toners are fused to the page by a process which uses a combination of heat and pressure. Liquid toners are fixed by air-drying or heating which evaporates residual liquid from the toner.

After the fixing step, the photoreceptor surface is cleaned to prepare the surface for further copying:

- **Cleaning step** - the toner remains on the photoreceptor are removed with a brush, cloth, blade or roller. An electrical charge helps to remove excess toner.
- **Erasing step** - a uniform light source floods the photoreceptor to neutralise residual charge.

Laser Printing

The laser printing process is very similar to the xerographic photocopying process. The major difference is that the exposure step for laser printers employs a laser beam to draw the image onto the sensitised surface forming a latent electrostatic image. Another difference is that generally laser printers operate at higher temperatures than photocopiers. It is therefore important that the moisture content of paper used in laser printers be controlled to prevent it from jamming in the printer and to avoid curling of the finished copy.

Colour Photocopying and Laser Printing

Both single colour photocopying and single colour laser printing are currently available. They employ the same technology as dry toner black photocopying and laser printing.

Full colour photocopying uses the same principles as the equivalent dry toner single colour xerography technology excepting that the process is repeated once for each primary colour. That is, each primary colour is separately laid onto the paper.

Full colour printers use an ink-based system and are not laser-based xerography technology.

Toners and Their Effect on Image Permanence

The quality and type of toner plays an important role in the permanence of printed electrostatic images. In today's copiers and laser printers, most toners are the dry powder or solid type, although liquid toners also remain in use.

Following is a summary of the composition and behaviour of various toners as well as a review of the factors that affect the performance of a toner.

Dry Toners

A typical dry toner is predominantly composed of a thermoplastic polymer, usually acrylic or styrene or both. The remainder of the toner consists of pigment such as carbon black. The toner must be such that it is a free flowing powder at ambient conditions as well as able to fuse readily during the fixing step. Dry toners mostly remain on the surface with little penetration of the paper fibres.

Liquid Toners

Liquid toners are composed of a suspension of pigmented or dyed resin particles in an insulating liquid. Charge control agents are added to impart an electrostatic charge on the particles. The liquid process involves washing or spraying the electrostatic image with this charged dispersion.

Liquid toner particles are significantly smaller than dry toner particles and usually contain acrylic resin combined with carbon black. Toner particle size is critical as it affects the resolution of the resulting image.

Images formed from liquid toners penetrate and colour paper fibres, unlike dry toners which adhere to the paper surface. Liquid toner images cannot easily be removed from the surface of the paper.

Liquid toner has some limitations. Even though the liquid carrier is fast drying, it does not evaporate instantly. Hence liquid-based systems work at about half the speed of the equivalent dry toner system. Also, images formed from the liquid process are prone to fading.

Carriers

"Carriers" are an active ingredient in a toner. They are used to generate a charge on the toner particles. The carrier is typically an iron or steel powder which may be coated with resin. The choice of carrier influences copy density, copy quality and halftone development. The presence of carriers in the image

formed on paper may have adverse effects on the stability and longevity of documents created by the liquid process.

Some toners do not contain carriers. These toners, known as "single-component", employ a magnetised roller to charge the toner particles.

Colour Toners

Colour toners are commonly based on organic dyes which are subject to fading and known to change colour. Xerographed documents which are to be retained for the long term should be made using dry toners containing pigments of known stability and on permanent or archival quality papers.

There is some speculation that the degree of fading or colour change of a pigment, organic or otherwise, depends on the other components contained in the toner, such as particular polymers or resins.

A recent study showed that various colour toners perform differently under identical irradiation with UV light sources. Colour toners which have pigment impregnated within a polyester resin showed better fusion with the page and the printed images were less subject to fading. This is because polyester is a good absorber of UV light. This theory is supported by the finding that photographs which are laminated or placed in polyester sleeves are less subject to fading.

Degradation of Toner Materials

Choice of toner depends largely on its particular characteristics and suitability for different applications. When choosing a toner for the creation of long term records, degradation of the toner should also be considered. Toner materials may degrade because of the following factors:

- heat
- oxidation
- chemical attack such as air pollutants
- physico-chemical changes such as separation of toner components
- physical processes such as changes in environmental conditions (temperature, relative humidity, pressure).

These degradation reactions may be inhibited with the use of specific chemicals that terminate the degradation reactions. Protection from light also helps. Carbon black, used in most black toner formulations, is a light blocker and absorber which also helps to prevent light-related degradation reactions.

Adhesion of Toner to Paper

The physical durability of a xerographed copy depends mostly on how well the toner adheres or fixes to the

paper. According to some studies the fixing of dry toners may be described as a three step process :

- sintering or coalescence of toner particles to form a melt
- spreading, flowing and penetration of the molten toner into the surface of the paper, ie, wetting of paper fibres
- cooling of the toner to form the fixed image.

It was noted that good adhesion was only achieved after thorough wetting. Time, temperature and pressure appear to be the important copy machine parameters in hot roll fusing.

Toner adhesion may be affected by the surface finish, smoothness and porosity of paper. It is more difficult for dry toners to penetrate coated papers and papers with small pore sizes.

Moisture content can be critical for the toner-to-paper transfer process and may also affect the fixing process. Electrical resistivity and surface energy of paper and toner have been reported to influence toner transfer and adhesion to paper.

Full colour images are thicker than black toner copies because they are composed of four layers of toner. Consequently, they do not fully adhere to the paper and are more prone to flaking during flexing or folding. Tape peel tests show that dry colour toner is easily lifted from the paper because the colour image is layered and thick. Colour liquid toner copies perform better than dry colour toner copies.

Colour liquid toner images are more subject to fading than dry toner images. This may be because they lack the protective polymers or resins contained in dry toners.

Testing the Image

It is sometimes desirable to evaluate the fix quality of a toner. Below is an outline of some of the tests which may be used to determine the fix quality:

- a rub test using a commercially available device called a crockmeter;
- an abrasion test - measures the retention of print contrast after abrasion, compared to a reference;
- microscopic examination of the print;
- a "tape peel" test - adhesive tape is attached to the print and gradually peeled back. Copies fail the test if any toner is removed by the tape.

Practical Recommendations

The durability of photocopied and laser printed documents depends largely on the quality of the paper used, as well as the degree to which the paper and

toner adhere after processing. Choice of pigment may affect the extent to which a document will fade, especially colour photocopied and laser printed documents.

Below are some recommendations which will enhance the permanence of photocopied and laser printed material for archiving:

- Print copies on permanent or archival quality papers. Watermarked papers should have the watermark towards the top of the page, or within margins or borders to minimise the amount of print over the watermark. This is because toner does not adhere as well to uneven areas of paper.
- Toners composed of stable resin materials and a stable pigment such as carbon black are capable of strong bonding to the paper surface. Copies using these toners and printed onto permanent or archival quality paper can be considered permanent and suitable for long term storage.
- Do not stack dry toner images horizontally or weighted at elevated temperatures (ie, above 20°C); do not place them in direct contact with vinyl and similar plastics (polyester film is safe) as this makes the toner sticky and capable of transferring to adjacent surfaces.
- Maintain copy machines to ensure that they are operating at the correct temperature to fuse the toner. The machine should be regularly serviced by a qualified technician.

There is sufficient evidence that colour xerographed images do not last as long as black and white copies. Most international archival institutions do not recommend the permanent or long term storage of colour photocopied or laser printed material. Below are some additional recommendations which will enhance the stability of colour photocopied and laser printed material for storage:

- Maximise the life of colour photocopied and laser printed copies by storing them in the correct environment (not exceeding 20°C, 50% relative humidity) and minimising exposure to light.
- Do not flex or fold full colour dry toner copies as the print layer is thicker and does not adhere to the paper as well as black toner copies.
- Store colour liquid toner copies away from all light sources to reduce fading effects.

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The information in this leaflet is current at 1 September, 1993. For further advice about its contents or an update, please contact the Custody & Preservation Section, Australian Archives Central Office, PO Box 34 Dickson ACT 2602. Telephone (06) 209 3967 or 209 3927, or fax (06) 209 3693. The Australian Archives' Regional Offices are listed on the next page.