印刷概论

Printing Brief introduction

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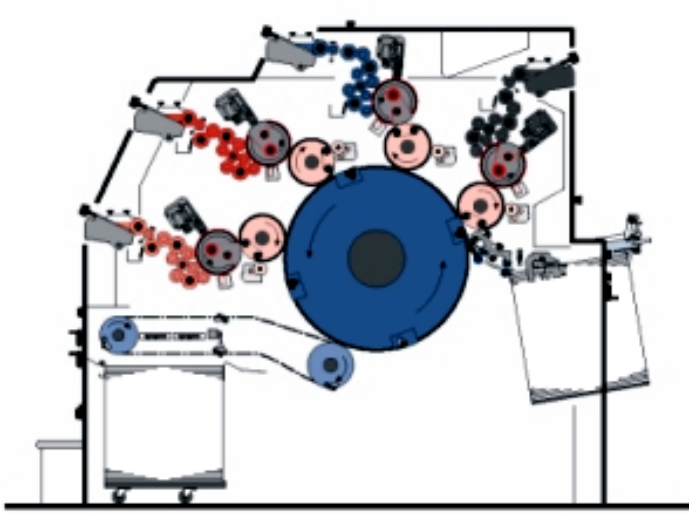
PRESS

- Relief / Flexo / Letterpress Printing
- Gravure Printing
- Screen Printing
- Lithography / Offset Printing
- DI Technology
- Non-Impact Printing
- Comparison of Printing Technologies
- Inline Finishing

DI Technology

- Introduction
- Platemaking
- Printing unit
- Substrates

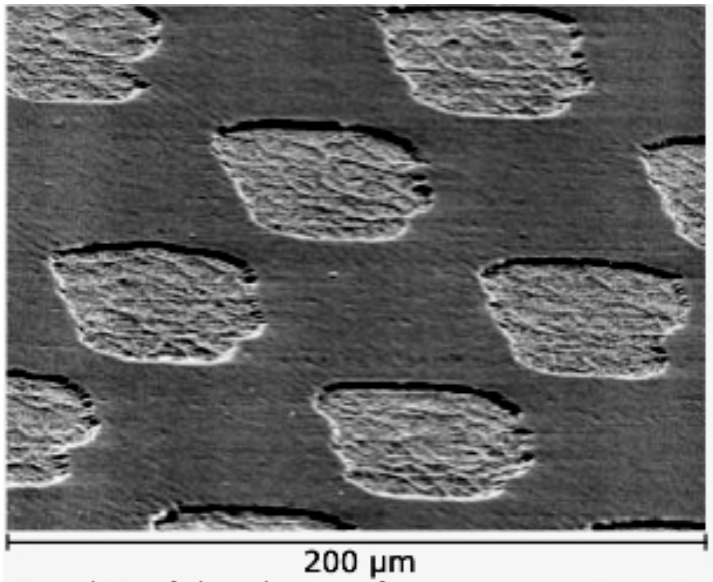
Introduction



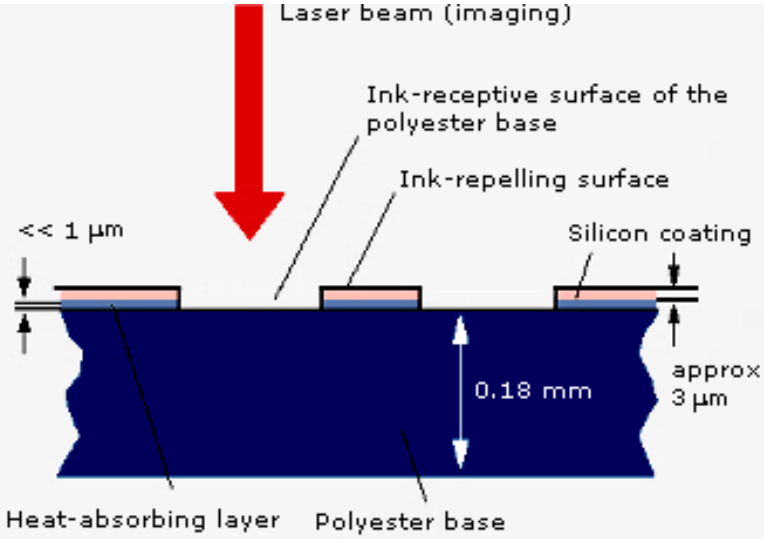
Schematic drawing QM DI 46-4

QM DI 46-4

With DI technology the plate is imaged inside the press. Plate imaging directly in the press is called computer-to-press.



REM shot of the plate surface



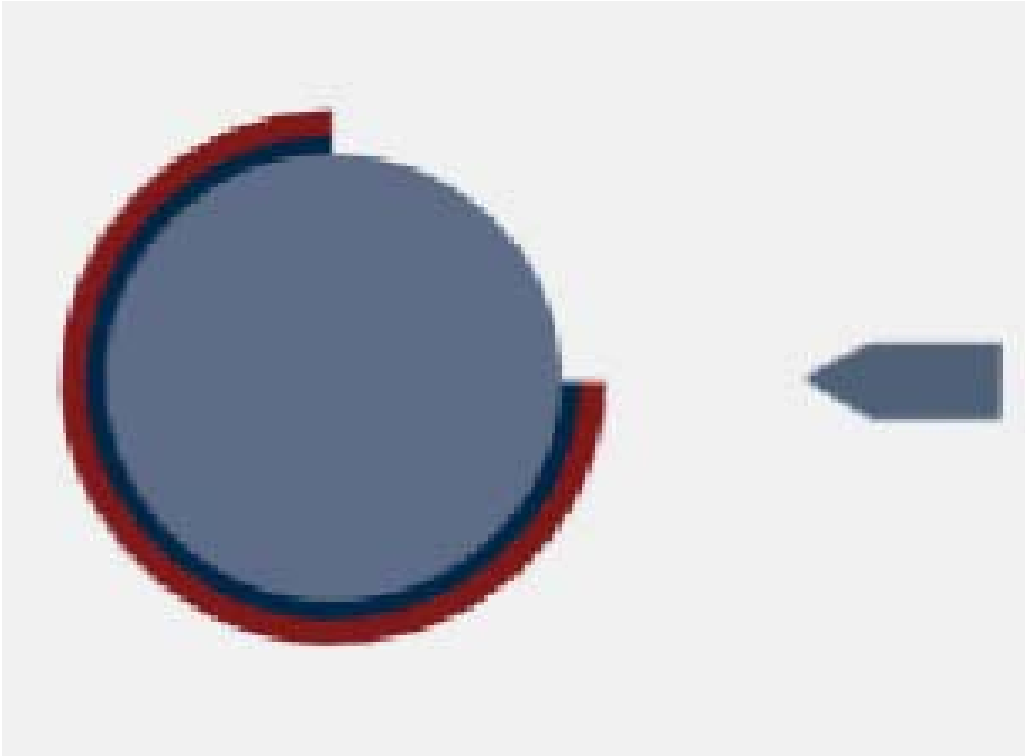
Sectional view of the plate

DI presses are usually based on the waterless offset technology. The plate material was specially developed for direct imaging and waterless offset. On the Quickmaster DI, for example, the material that carries the image is a foil. The entire surface of the plate is initially ink-repelling, which is achieved, for example, through a silicone coating. Only by the targeted application of heat and detaching of this layer with a laser is the ink-receptive layer underneath exposed.

Detail of a printed multi-color image with 60 lines 1270 dpi

Detail of a printed text GTO DI

Here you see details of a printed image and a printing plate. The plate was exposed with a laser at a wavelength of 830 nm. The top layer is heated up and separated which reveals the image-carrying elements underneath. This process is called ablation.

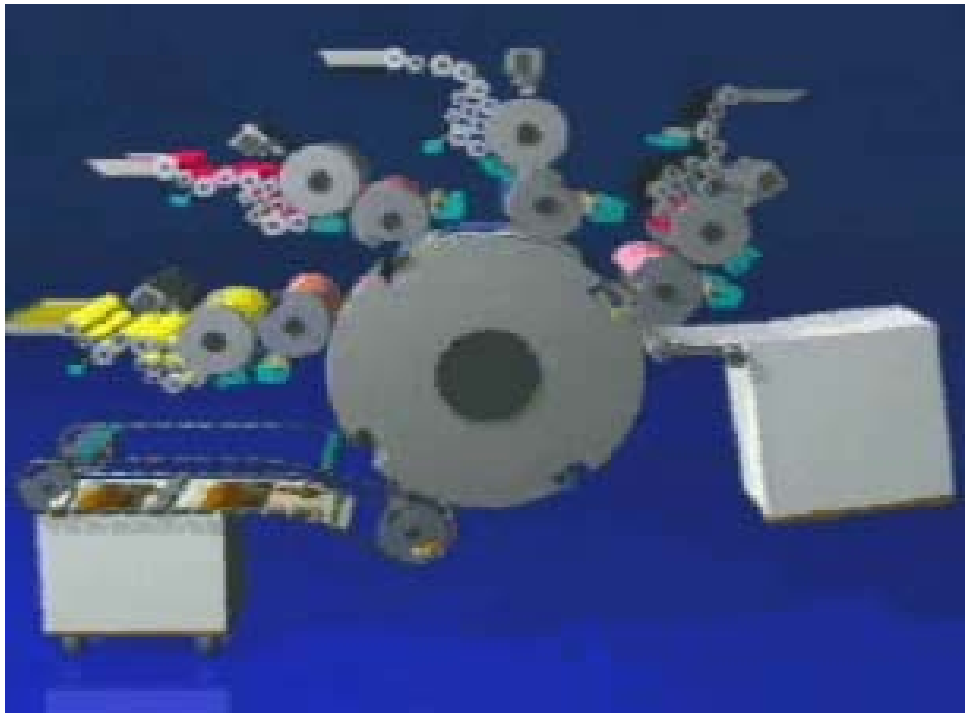


Imaging principle with the DI technology

Platemaking

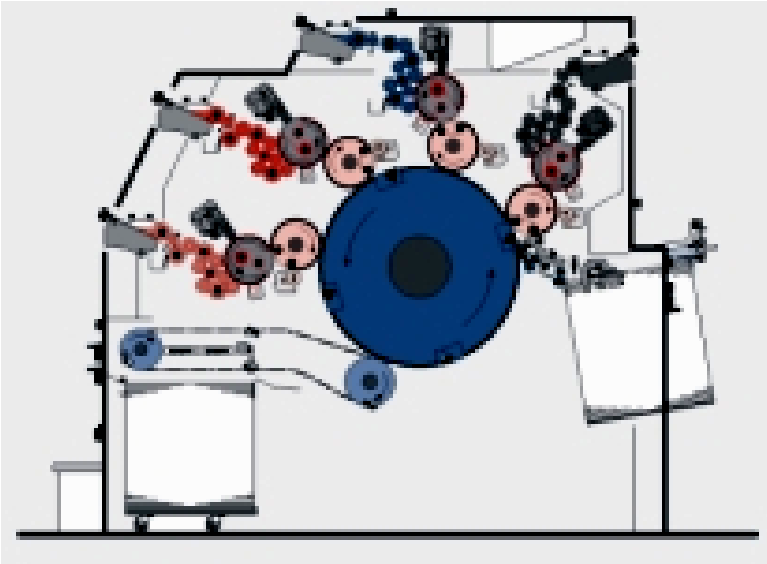
QM DI 46-4

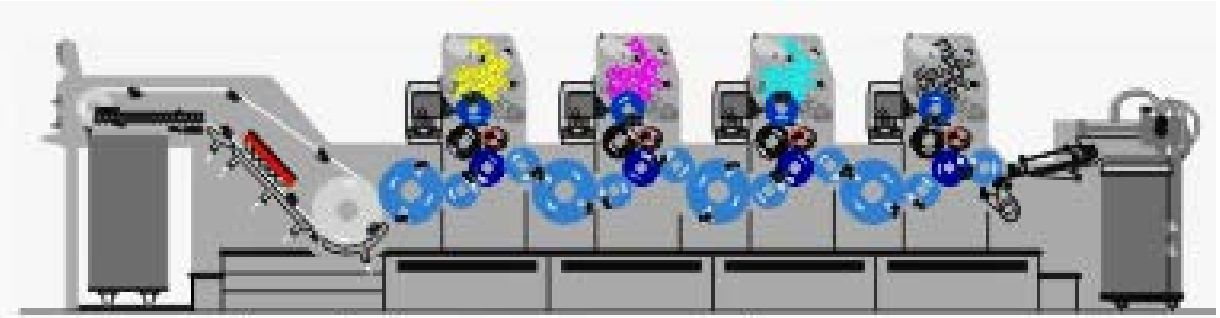
This video gives you an idea of the imaging process taking place in a QM-DI from Heidelberg. Up to 35 different four-color jobs can be imaged with one printing plate cassette.



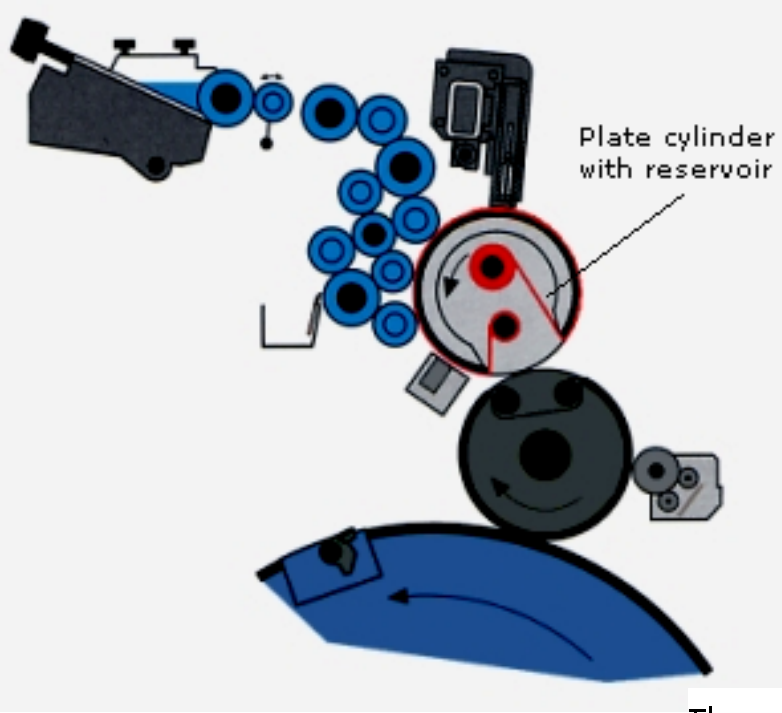
QM DI 46-4 imaging process

Printing unit





Sectional view of the QM DI 46-4 and SM 74 DI



The printing units of DI presses are available without a dampening system, such as the Quickmaster DI, or with a dampening system, like the Speedmaster 74 DI. The Speedmaster 74 DI is based on the conventional offset technology and uses a special printing plate that is suitable for direct imaging.

Substrates

DI products

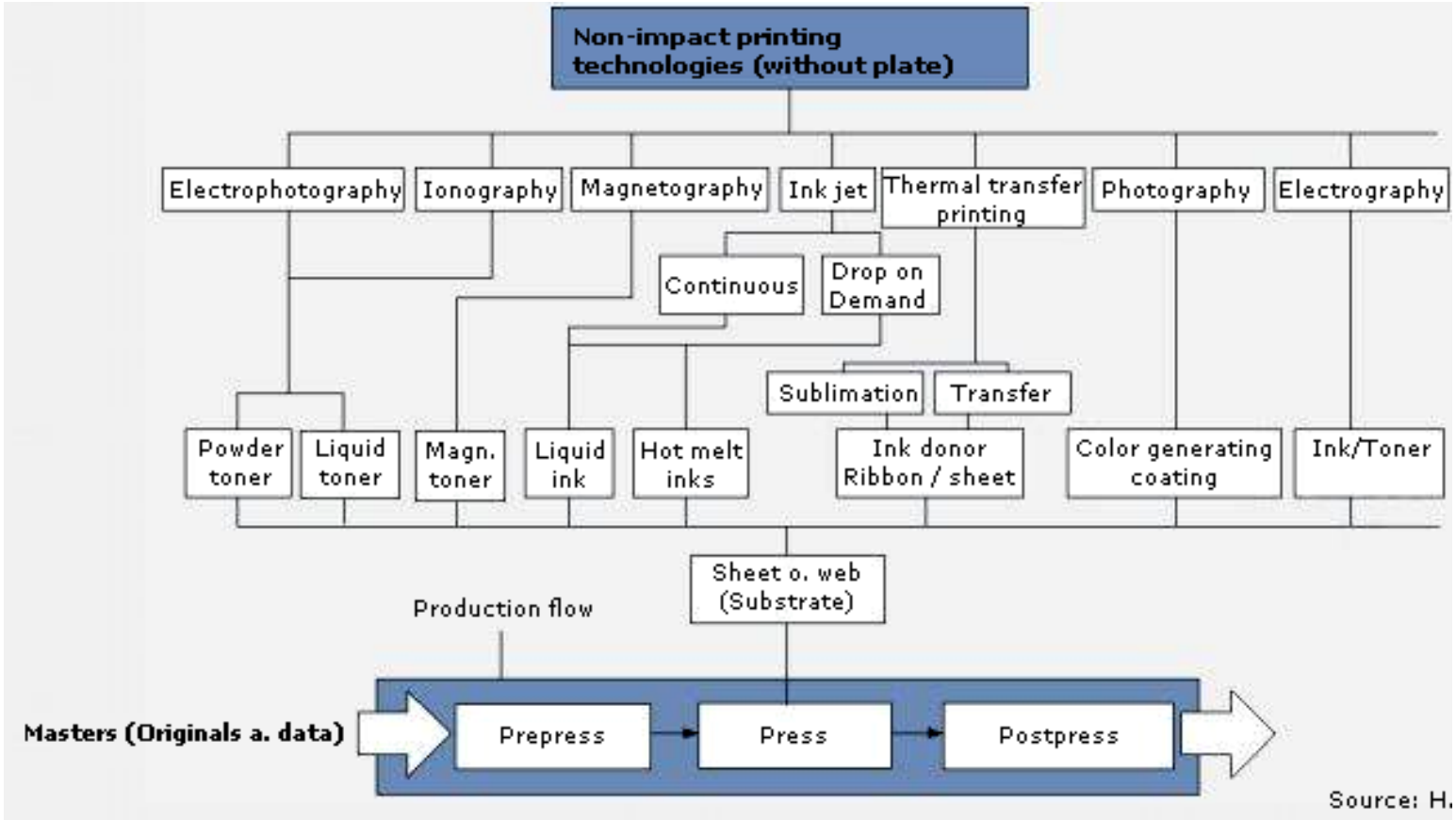
Offset printing products

DI presses do not require special types of substrates, they can print the same ones as used in conventional offset, however, they are more geared towards short runs and frequent job changes.

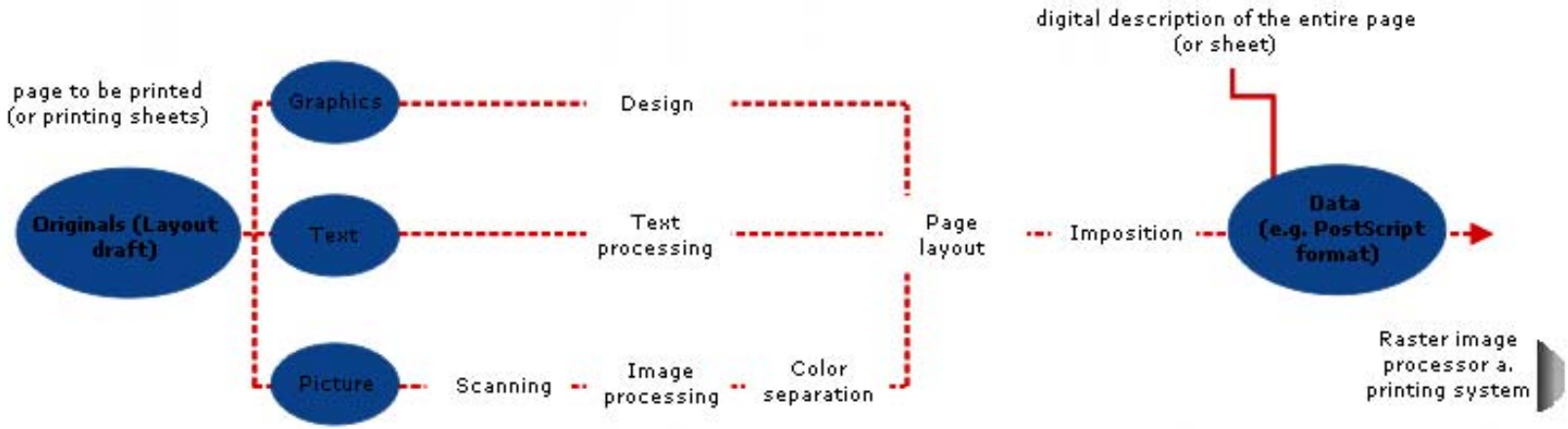
Non-Impact Printing

- Introduction
- Inkjet
- Electro-photography
- Iconography
- Magnetography
- Thermography
- Electrography
- Photography
- Comparison of Printing Processes

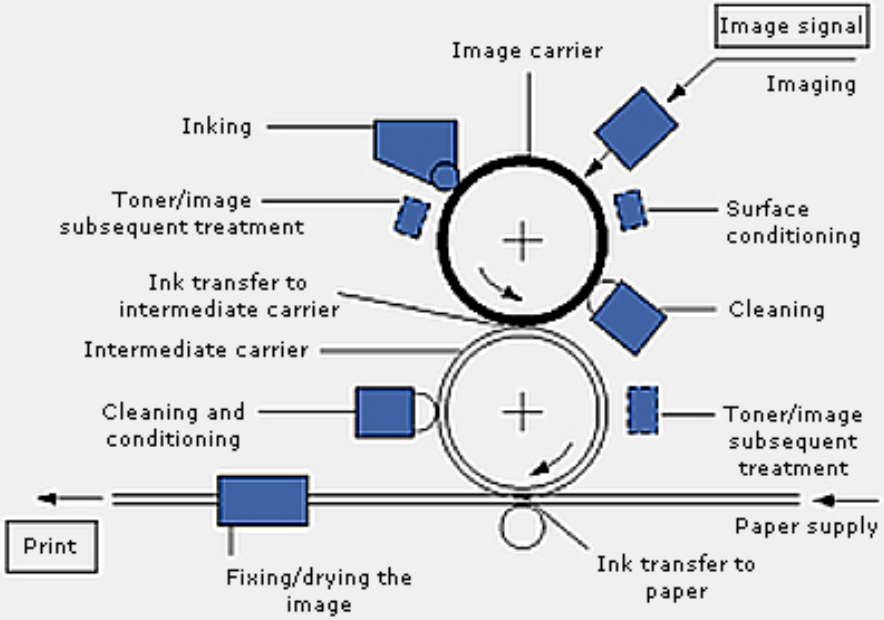
Introduction



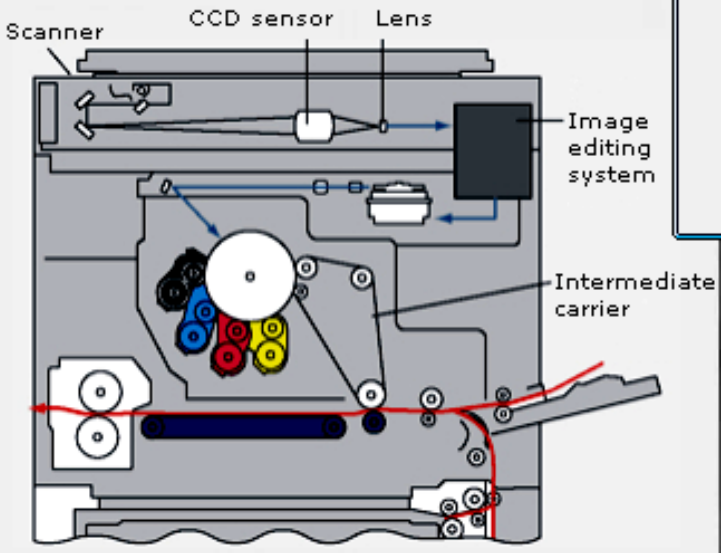
Here we have drawn up an overview of digital printing technologies. All these processes have no fixed-image plate and can print a different content print-for-print.



The workflow in digital printing usually involves text, picture and graphics data being electronically processed and set in a layout program. The program then generates a file, for example, a Postscript file, which is interpreted and printed directly by the digital printer.

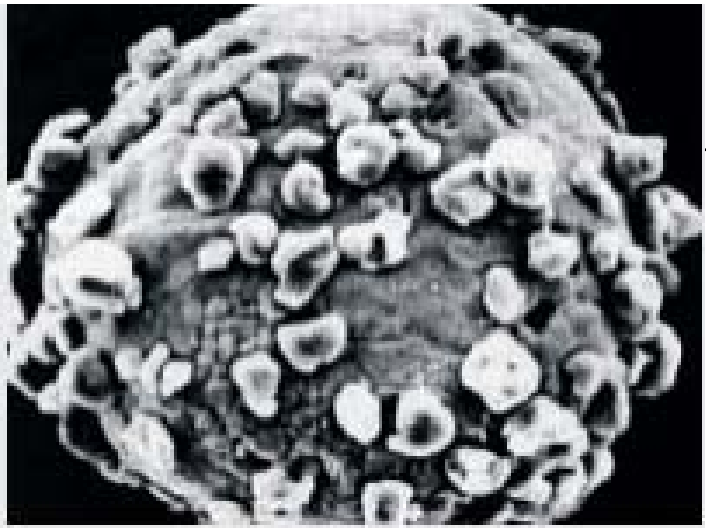


Functional units for printing systems based on NIP technologies



Multipass system for multi-color printing

Some of the digital printing technologies require intermediate carriers. These could be a ribbon, foil or drum which buffers the print image and then transfers it to the substrate.



Two-component toner on a carrier

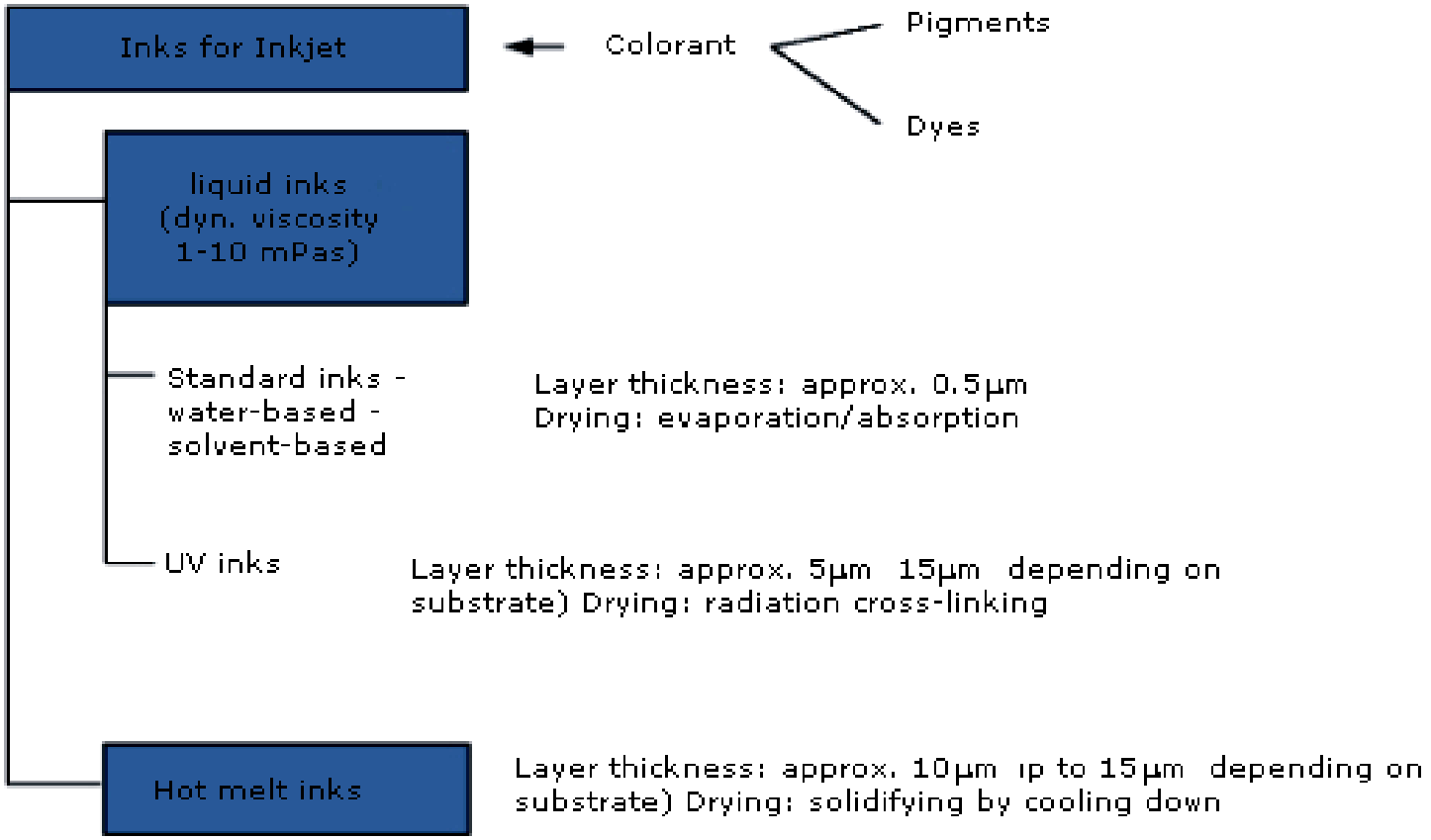
Here is a two-component toner. The carrier holds the minute toner particles for the imaging process. The carrier is then collected in the developing unit for recycling.

Mechanically produced toner (AGFA)

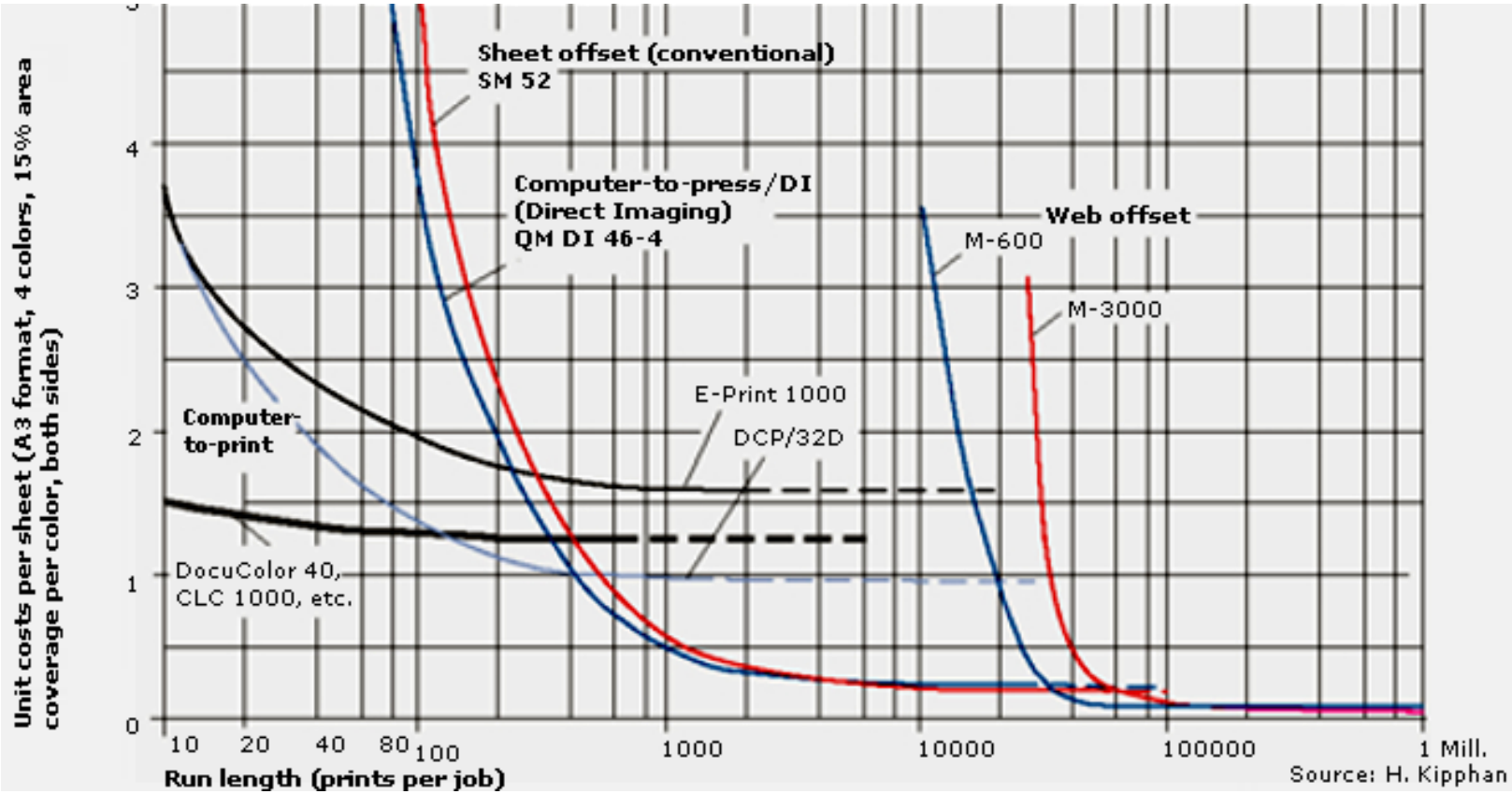
This is a single-component toner produced by mechanical processes. The basis of this toner is a granulated material created in several rounds involving melting, grinding and classifying.

Chemically produced toner
(OKI Data)

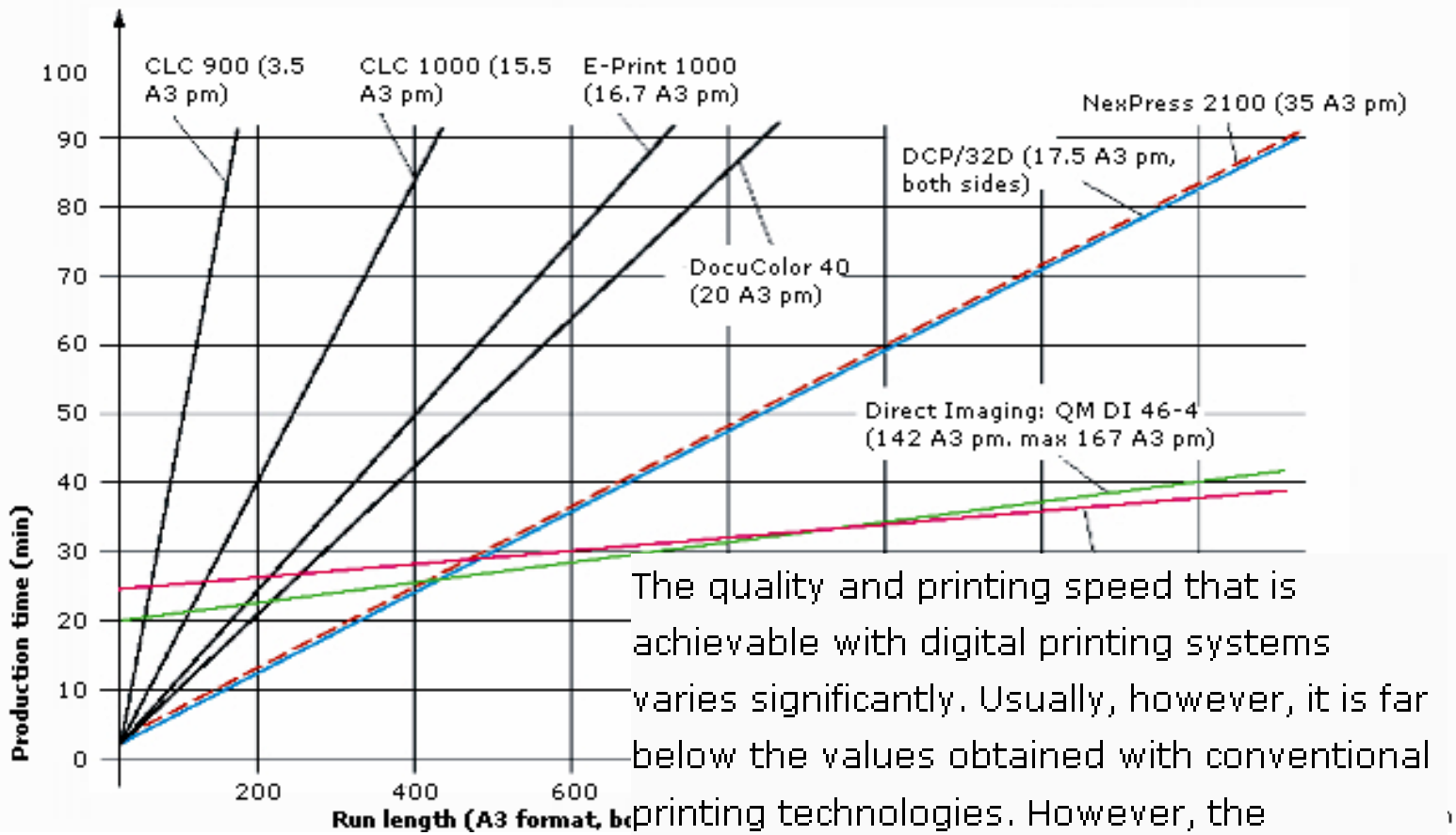
This round-grain single-component toner has been produced by direct chemical synthesis from dispersions.



Some digital printing technologies require ink for transferring the image information to the printing material. The inks are either pigmented or contain dyes.



Digital printing technologies are economical for short print runs. Starting at a run length of around 400 copies it is worthwhile to employ a direct imaging press, for example, a Quickmaster DI.



The quality and printing speed that is achievable with digital printing systems varies significantly. Usually, however, it is far below the values obtained with conventional printing technologies. However, the development in this field is making great leaps forward. We can certainly expect improvements in printing quality and speed.

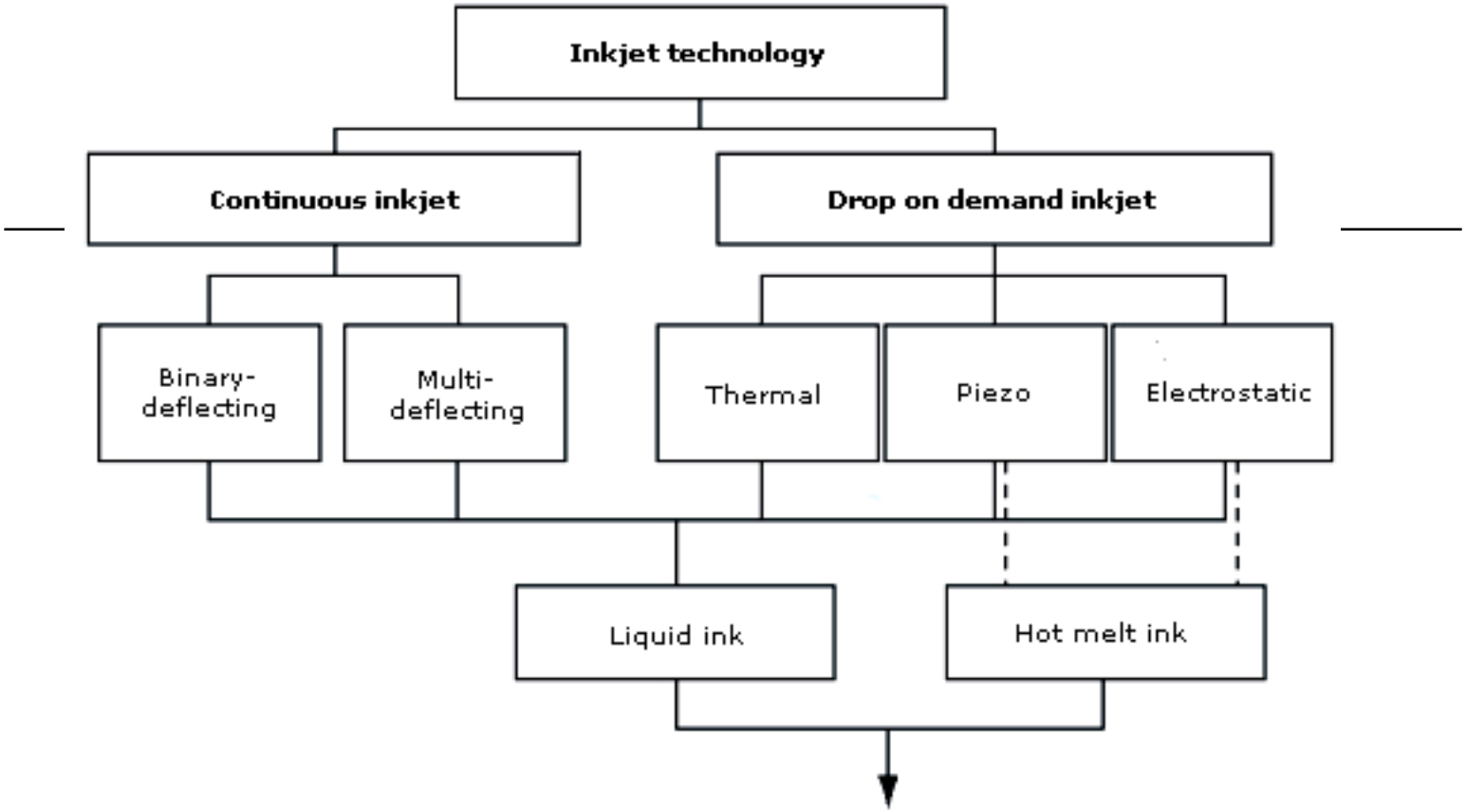
NIP Inkjet

- Introduction
- Continuous
- Drop on demand
- Piezo
- Thermal
- Electrostatic
- Substrates
- Systems

Introduction

Large-format inkjet printer

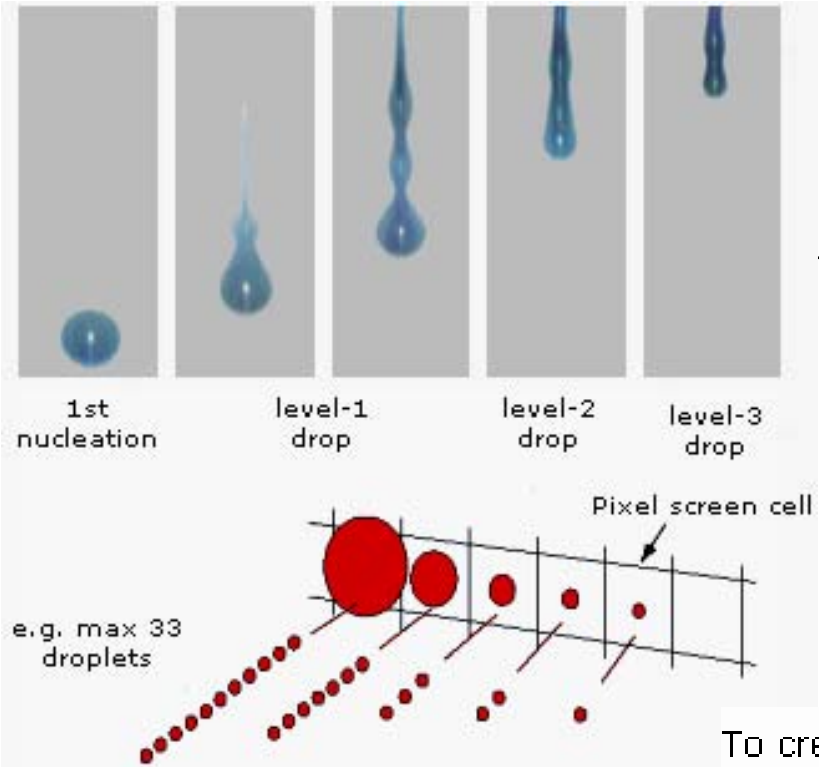
The idea of creating an image by means of ink droplets dates back more than 100 years, but this technology has only been utilized in printers since 1970. Today, inkjet printers are available for the most diverse resolutions and quality requirements.



Overview of different inkjet technologies

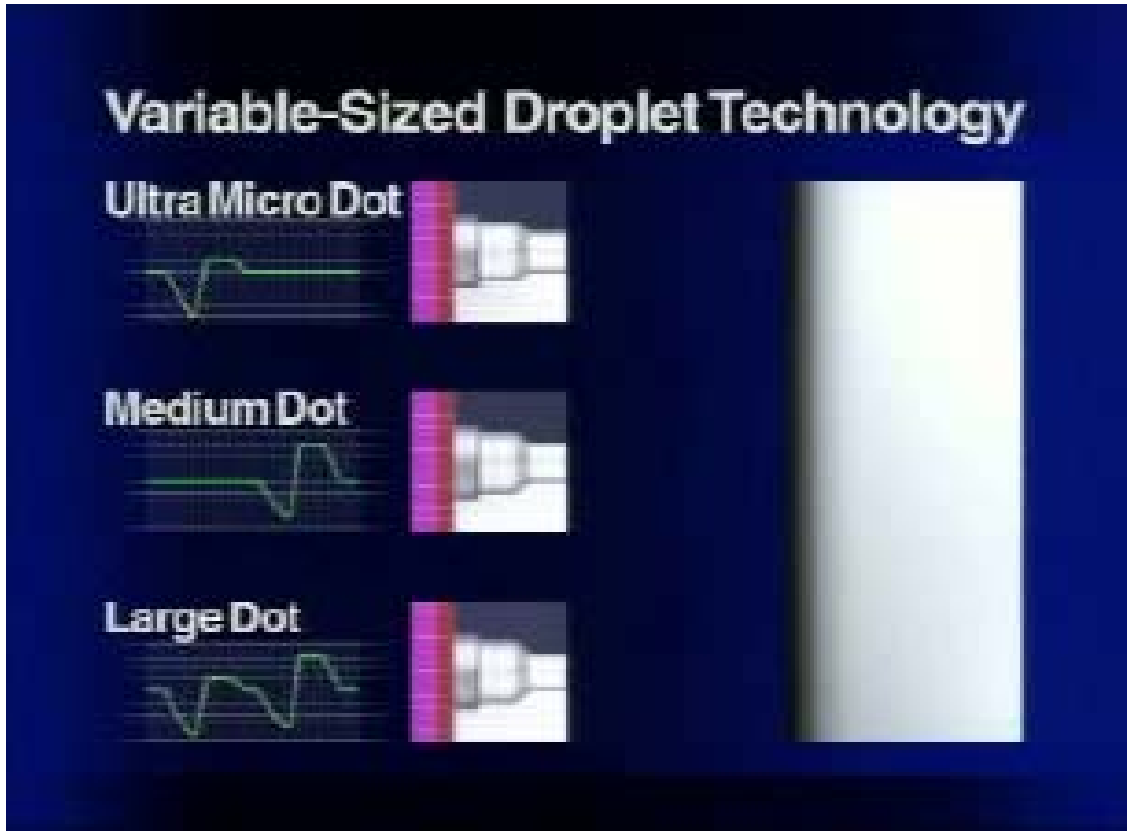
Source

Here you can see an overview of the technologies in the field of inkjet printing.

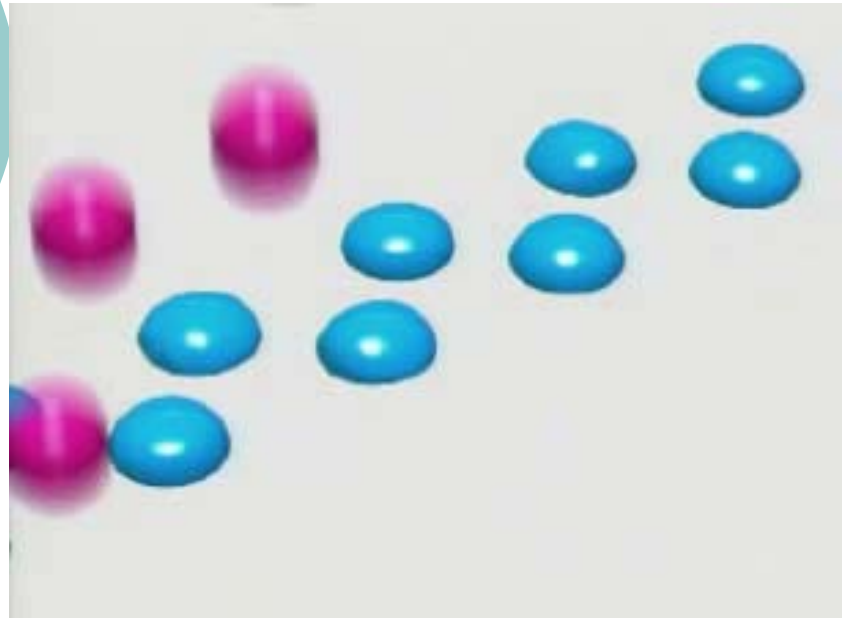


Forming a dot from individual droplets

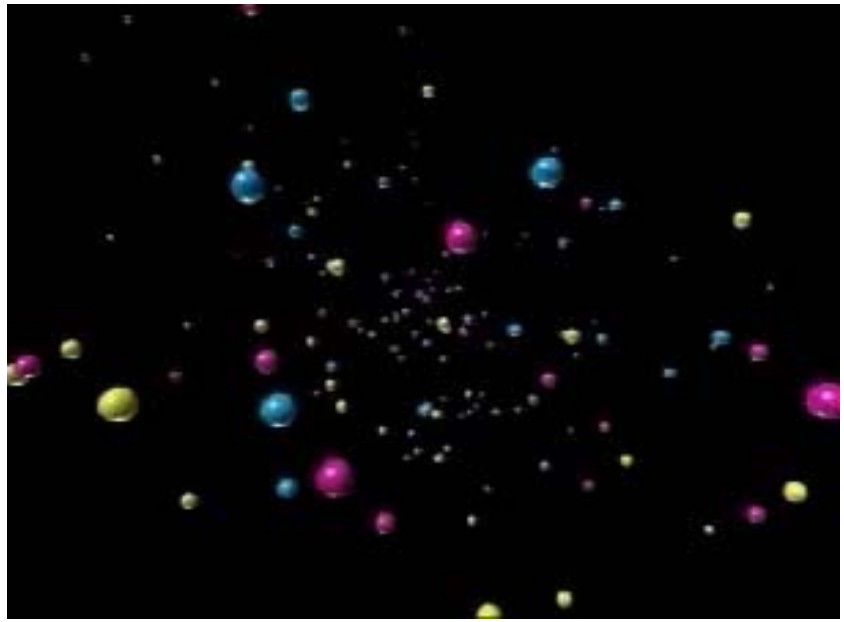
To create gray values with inkjet printers, the ink must be sprayed onto the substrate in layers of different thickness. In principle, a droplet with a higher layer thickness will also require more space. The gray values are achieved by printing several droplets on top of one another on the same spot. The video illustrates how this process works.



Droplet size

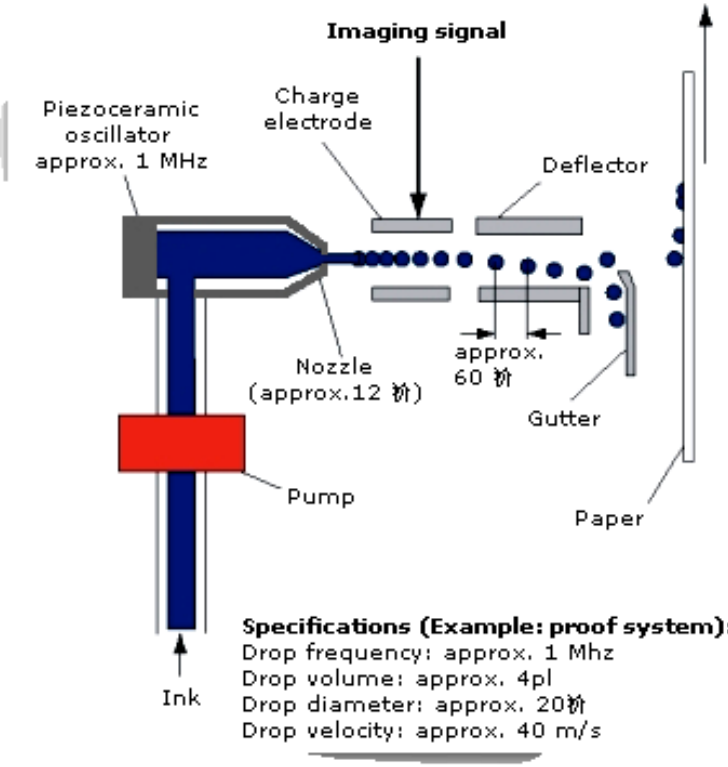


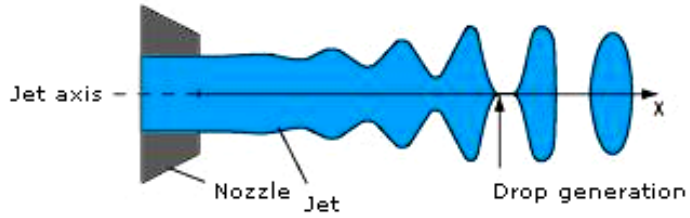
Normal ink



Quick-drying ink

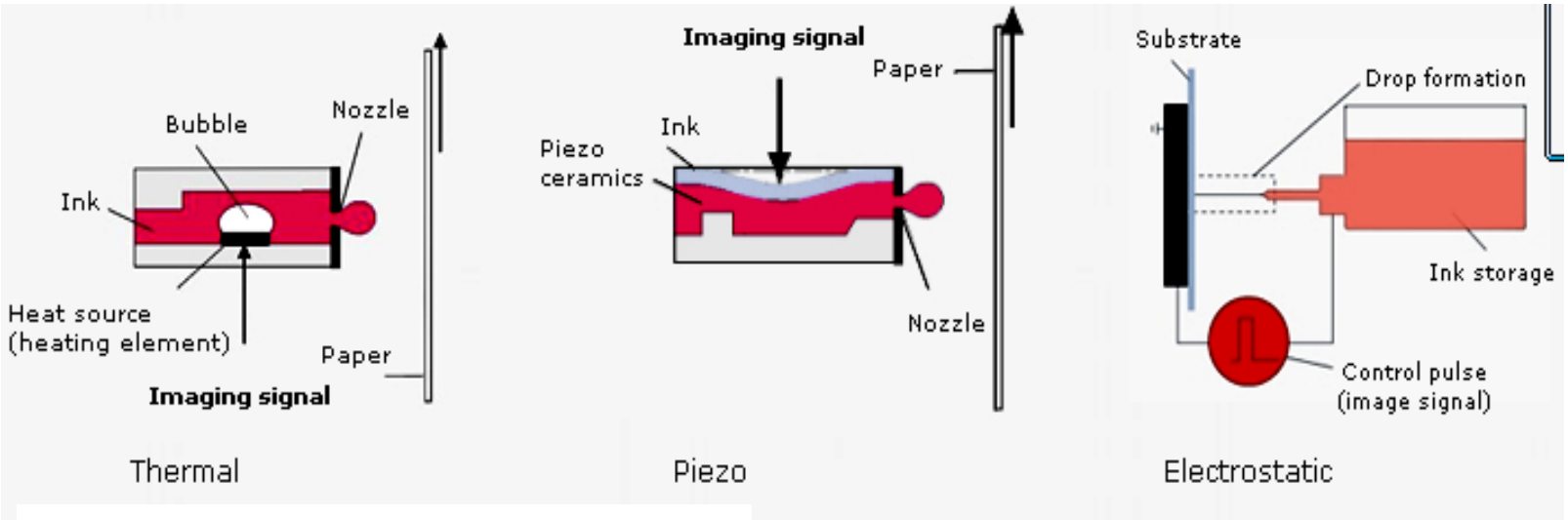
Continuous





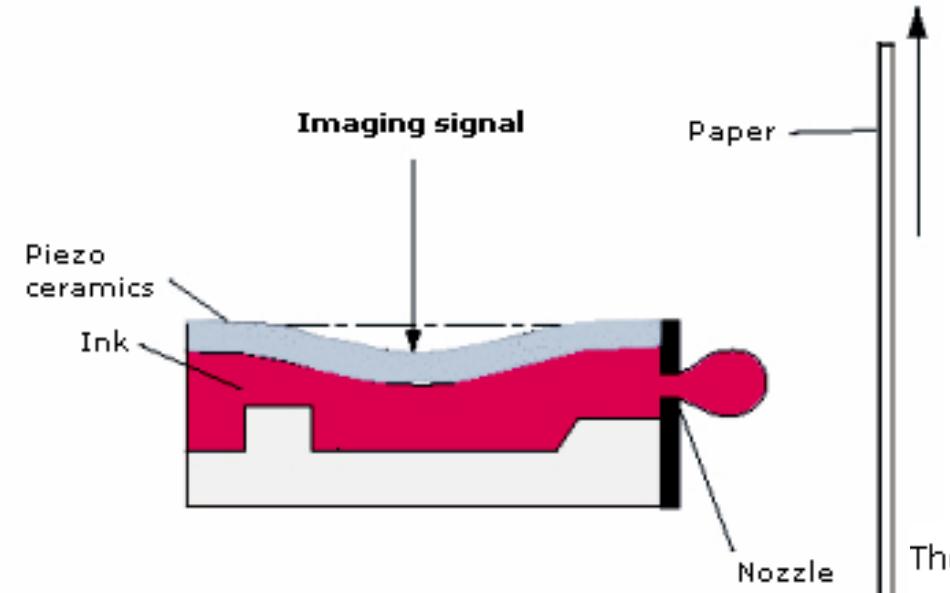
Here you can see the schematic diagram of a continuous inkjet system. In this process a high-frequency jet of droplets is generated. High-frequency stimulation by a piezoceramic oscillator causes the jet to contract and thereby form separate droplets.

Drop on demand



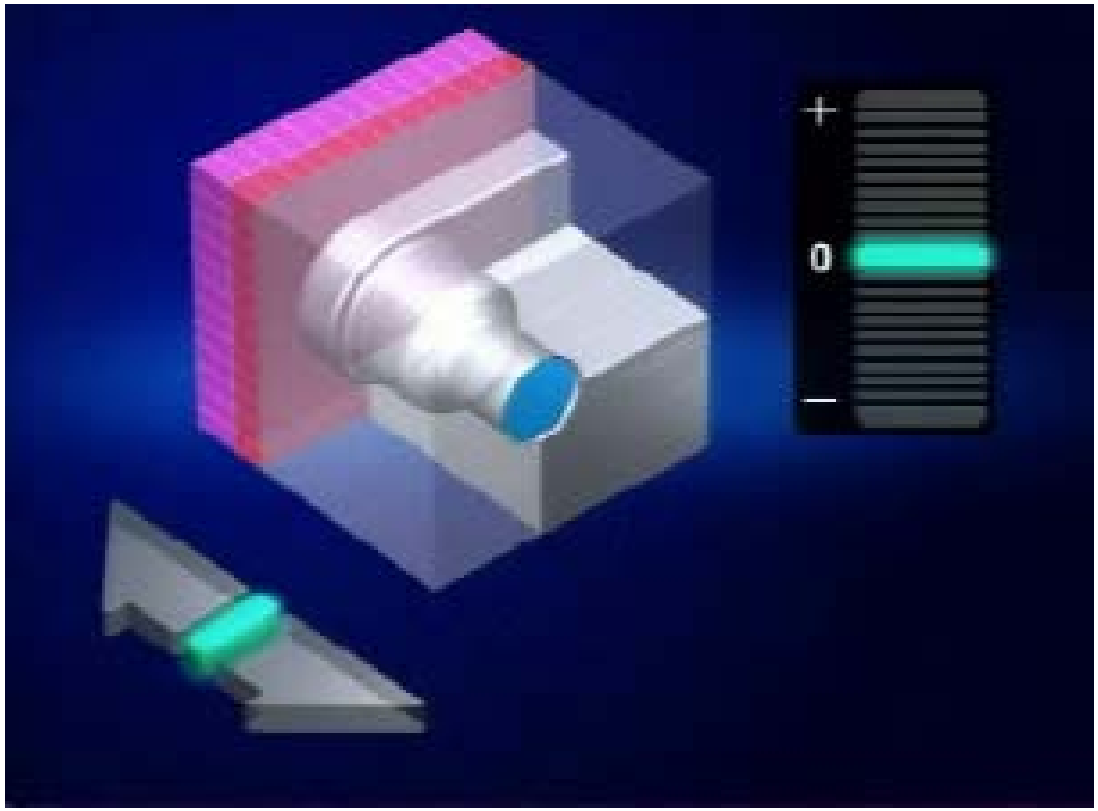
Drop on demand is an intermittent inkjet printing technology. The ink droplet is only produced when it is required in the print image. There are three different drop on demand technologies: thermal inkjet, piezo inkjet and electrostatic inkjet. In thermal inkjet technology, the droplets are produced by adding heat, in piezo inkjet technology by altering the cross-section of the nozzle aperture, for example; and in electrostatic inkjet by an electric field between inkjet system and the surface to be printed.

Piezo



Specifications (Example):
Drop frequency approx.10-20 Mhz
Drop volume: approx. 14pl
Drop diameter: approx. 30 μ

The piezo technology is used in inkjet printers from Epson, for example. The piezo ceramics are deformed by applying a voltage. If the ceramic expands into the channel as shown in the illustration, a drop of ink is ejected out of the nozzle onto the paper.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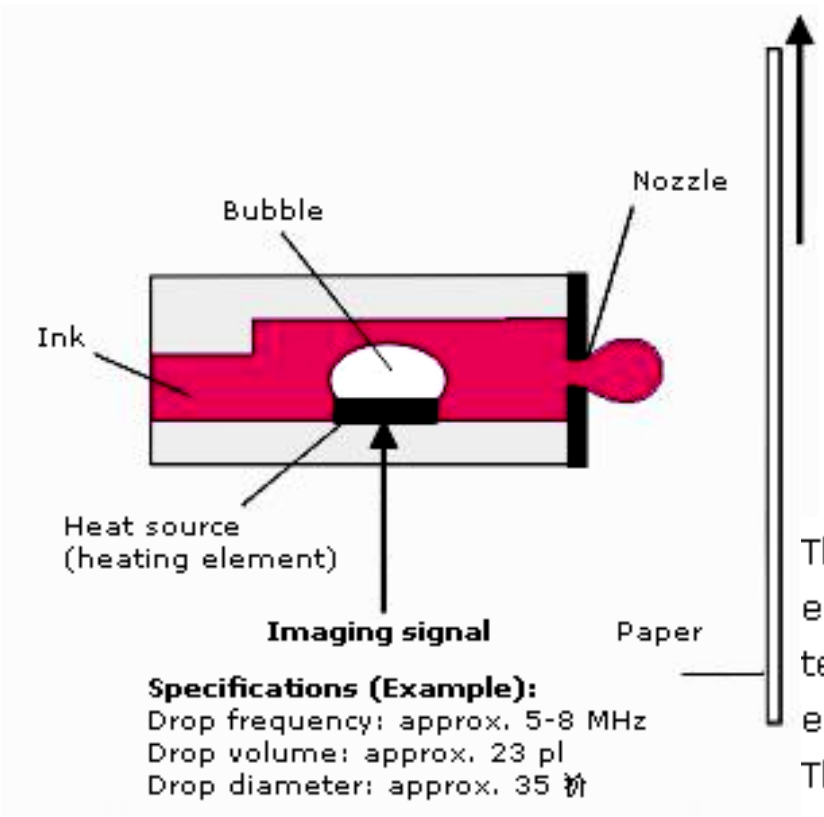
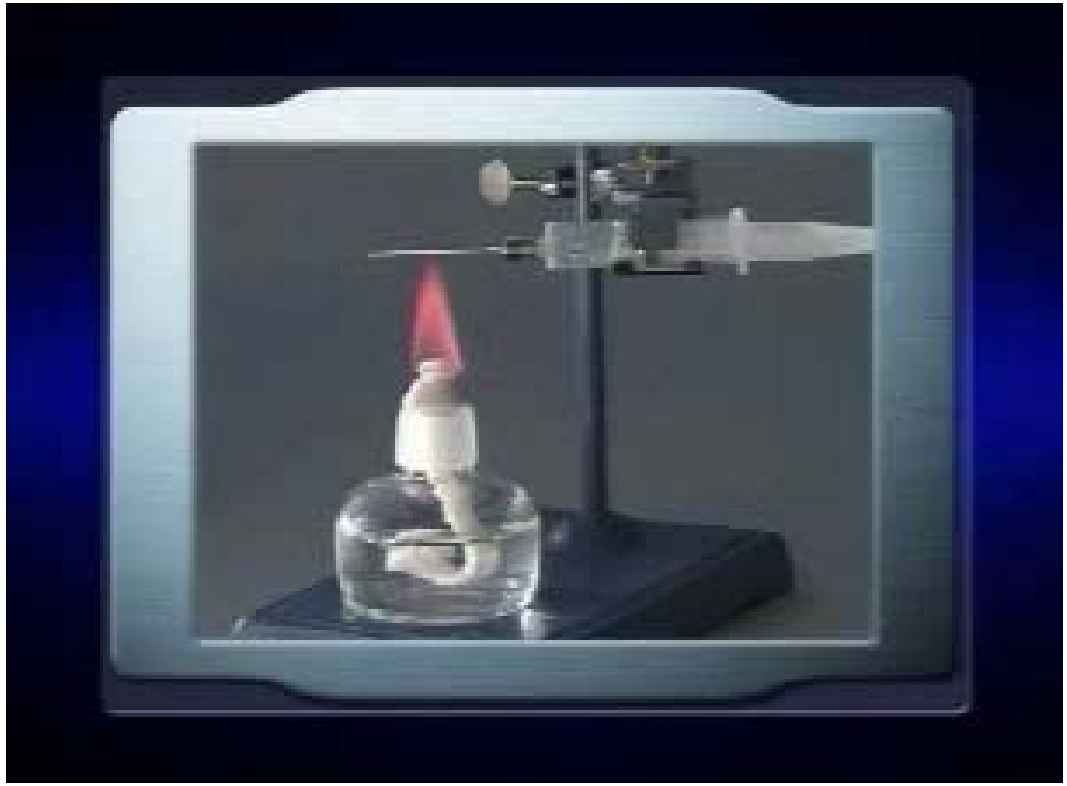
Thermal

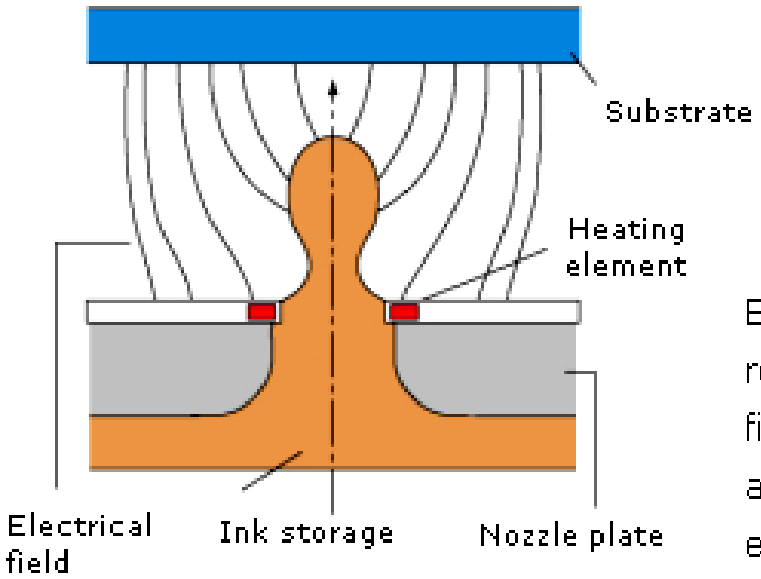


The printers from Canon and HP, for example, are based on a thermal ink technology, called bubble jet. A heating element is heated up by the imaging signal. The ink evaporates and thereby generates an evaporation bubble, i.e. overpressure. As a result, a droplet is ejected from the nozzle.

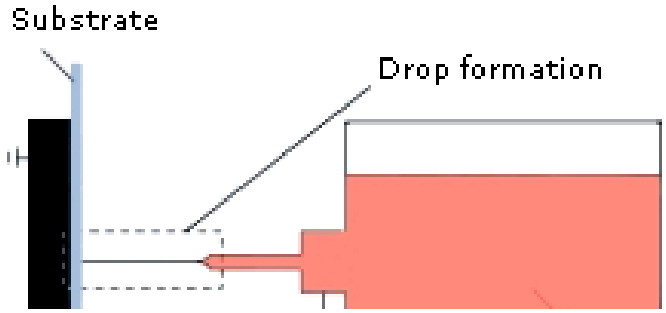


Principle of thermal inkjet

Electrostatic

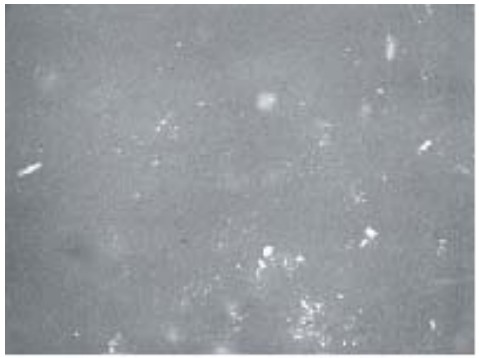


Electrostatic inkjet (still in its laboratory test phase)
Source: H. Kipphan

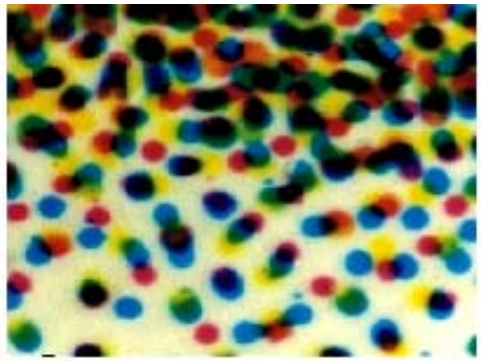


Electrostatic ink-jet printing is still a relatively young technology. Here an electric field is generated between the substrate and ink storage. The edge of the nozzle is enclosed by a ring-shaped heating element. A current pulse is sent through the heating element which heats up the ink and liquefies it in this area. This alters the surface tension in the vicinity of the nozzle and produces a drop.

Substrates

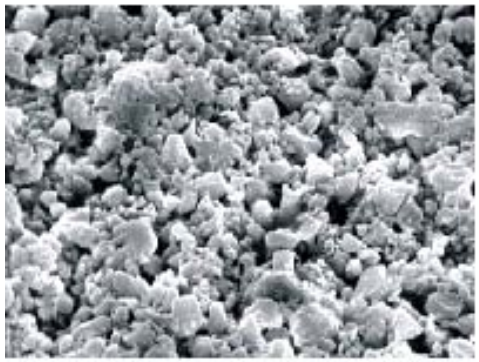


Cast-coated inkjet papers

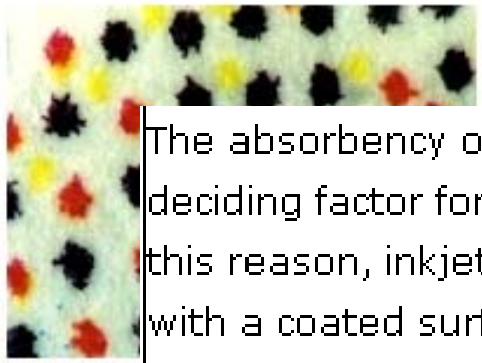


Inkjet dots on cast-coated papers

Inkjet ink for cast-coated paper



Matt coated inkjet paper



Inkjet dots

The absorbency of the substrate is the deciding factor for the printing quality. For this reason, inkjet printers require paper with a coated surface that properly absorbs the dampness from the ink, but still produces dots with defined edges.

Systems

Inkjet technology of piezo drop on demand
Source: H. Kipphan

Inkjet technology of thermal drop on demand
Source: H. Kipphan

The following pages contain different types of inkjet printers for different ranges of application.

Inkjet system for multi-color proofs

Inkjet system for multi-color printing of large formats

The color proof printer on the left prints sheet sizes of up to A2+ with a resolution of 600 dpi. The color proof printer on the right images sheet sizes with a maximum image width of 1340 mm using the thermal ink-jet process at a resolution of 600 dpi.

Piezo drop on demand inkjet for multi-color prints up to an image width of 5 m

Continuous inkjet for multi-color prints up to an image width of 5 m

These two inkjet systems cater for widths of up to 5 meters with resolutions between 19 dpi and 300 dpi. The relatively low resolution is hardly noticeable on posters or billboards since the images are usually viewed from a great distance.

NIP Electrophotography

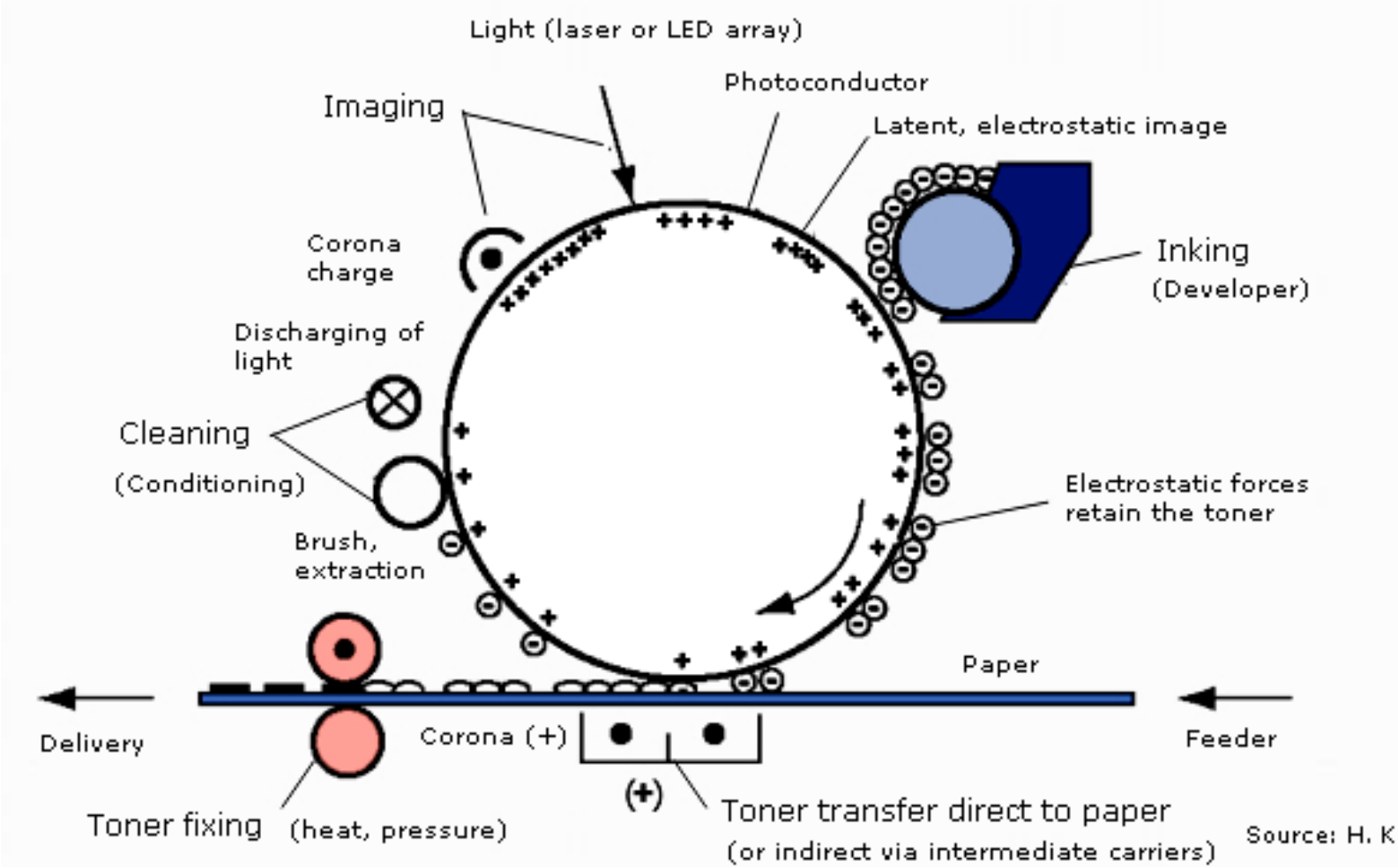
- Introduction
- Processes
- Substrates
- Systems

Introduction

Office laser printer

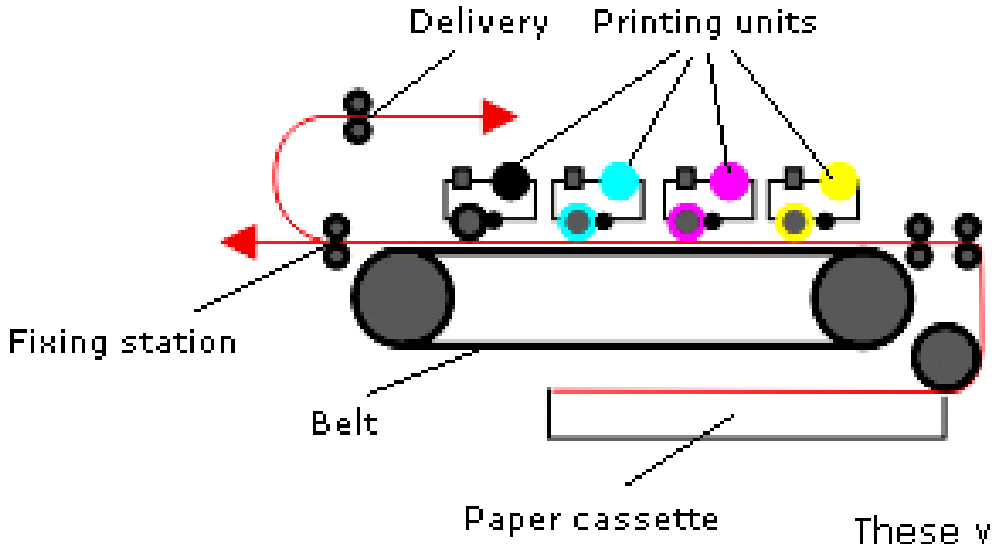
The Digimaster digital press

Electrostatics compirses the technologies of electrophotography and electrography. Today the technology of electrophotography is used in most copiers and laser printers and is by far the most wide-spread digital printing technology.



The principle of electrophotography is shown here. The process can be broken up into five steps.

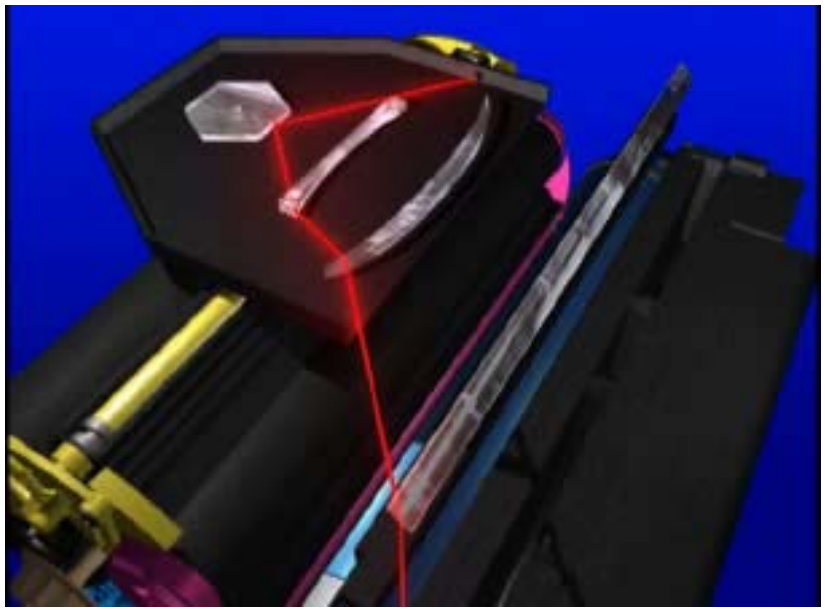
Processes



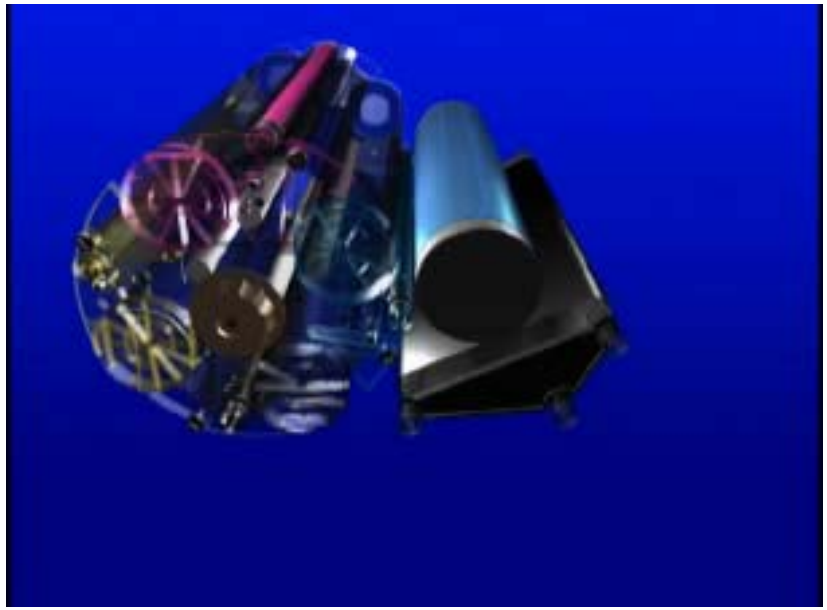
Sheet travel on the photoconductor drums

These video shows a laser printer with the individual photoconductor drums arranged in a line. Each color has its own photoconductor drum and transfers the toner directly to the paper. The photoconductor drum is imaged via an LED array.

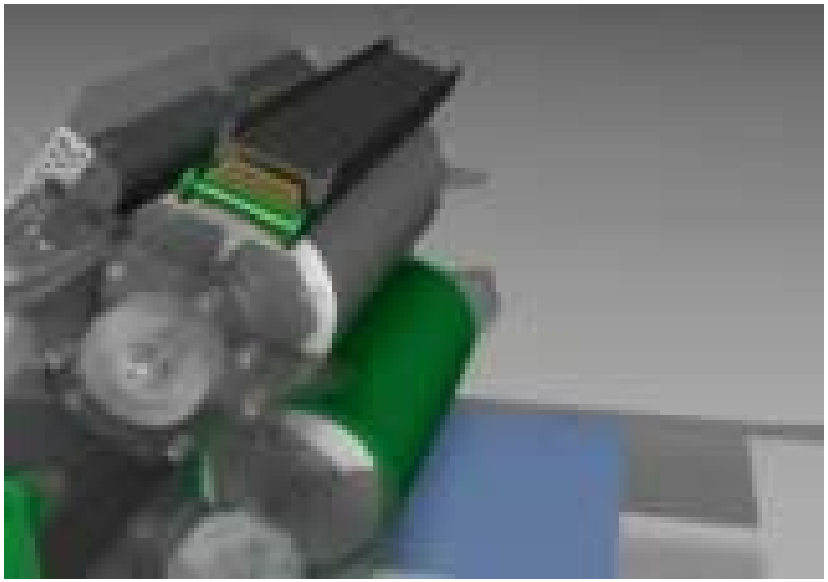
Exposure of the photoconductor drums via an LED array



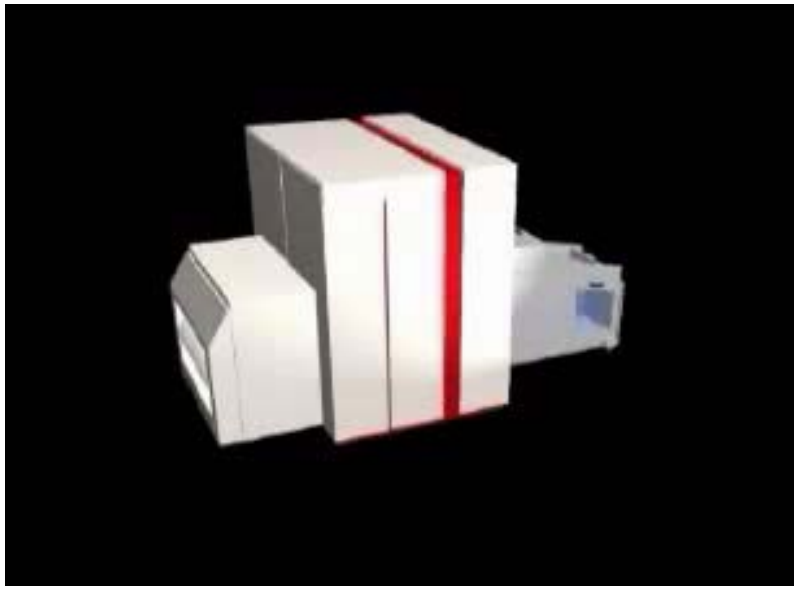
Imaging with laser and a rotating polygon mirror



Multi-color laser printer with intermediate image carrier

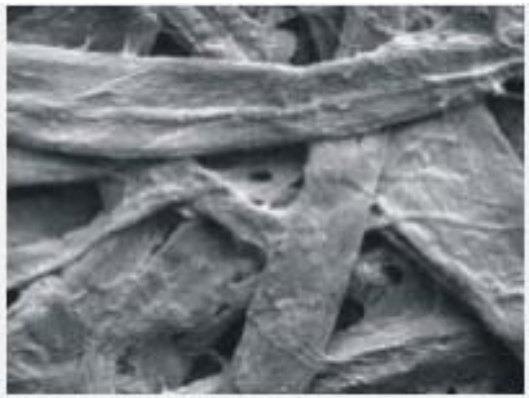


Printing unit on the NexPress 2100

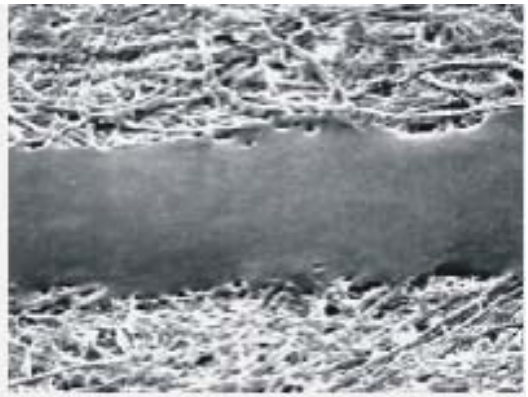


Printing unit on the DCP 32D

Substrates

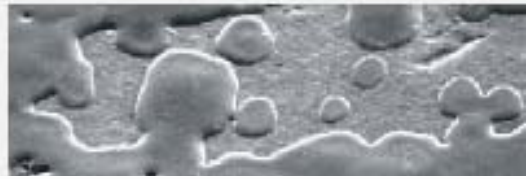


Uncoated paper for electrophotographic printing



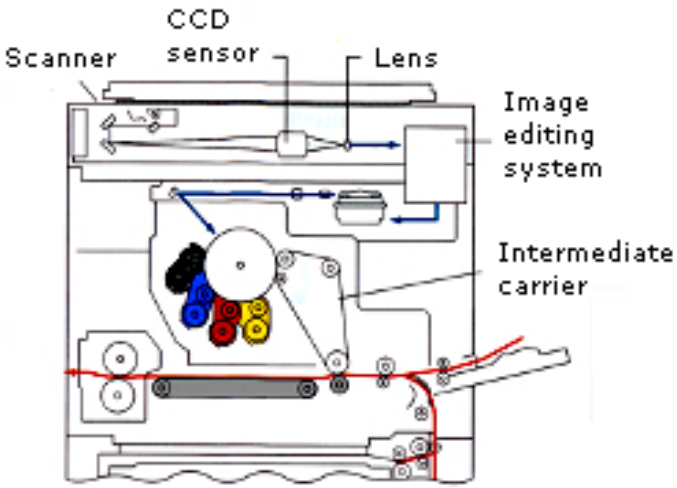
Toner on uncoated paper

Cast-coated paper for electrophotographic printing



All substrates which can be transported through the press and withstand fixation of the toner particles by heat are suitable for electrophotographic printing.

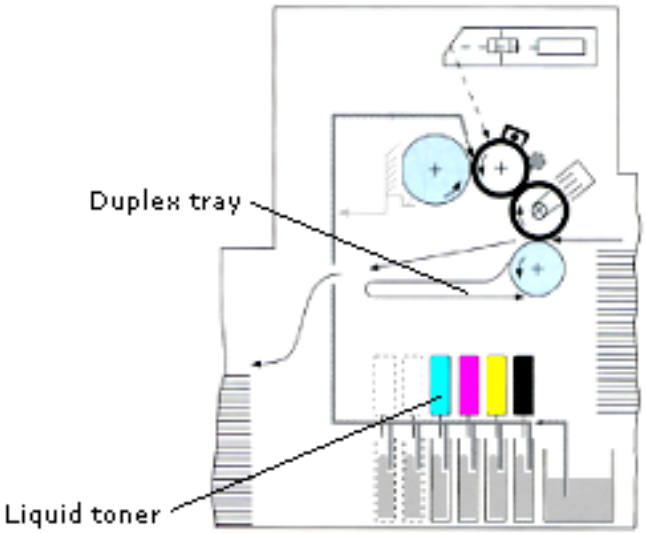
Systems



Multi-color printing with intermediate carriers and dry toner

Source: H. Kipphan

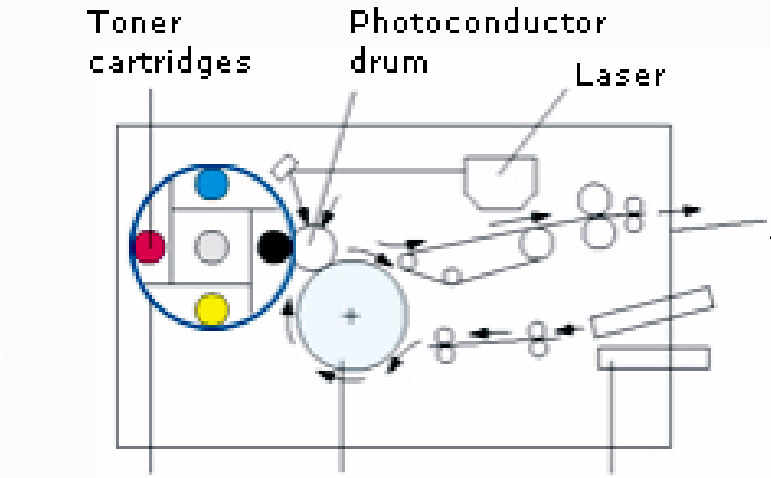
This is a multipass system for multicolor printing. The inking units are arranged as satellites around a photoconductor drum. The toner is transferred to the paper via an intermediate carrier.



Multi-color printing with intermediate carrier and liquid toner

Source: H. Kipphan

This multipass system for multicolor printing operates with a switchable supply of liquid toners and collects the color separations on the impression cylinder while holding the sheet in position. The toner is transferred via an intermediate cylinder.



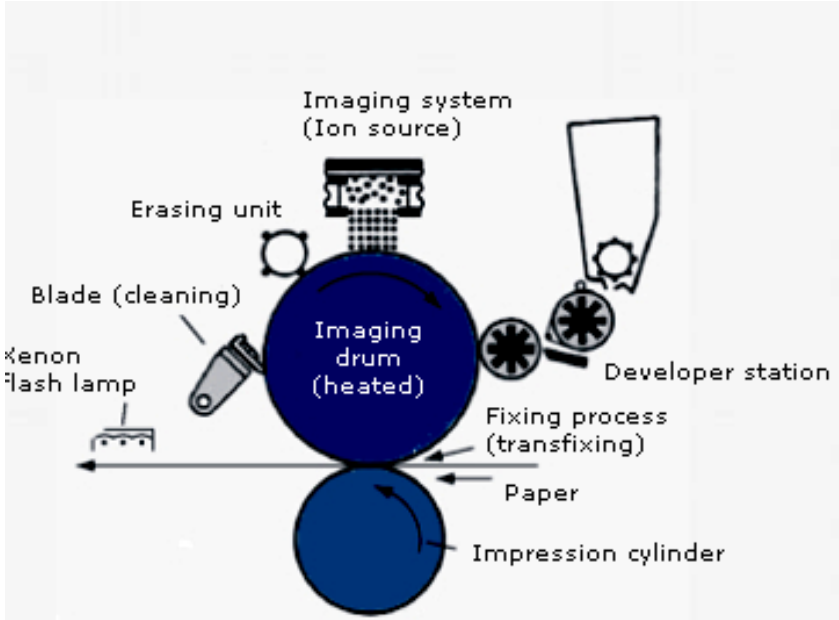
Multi-color printing without intermediate carrier, using dry toner via a carousel system

In this multipass system the toner cartridges revolve around the photoconductor drum in the manner of a carousel. The toner is transferred directly to the paper.

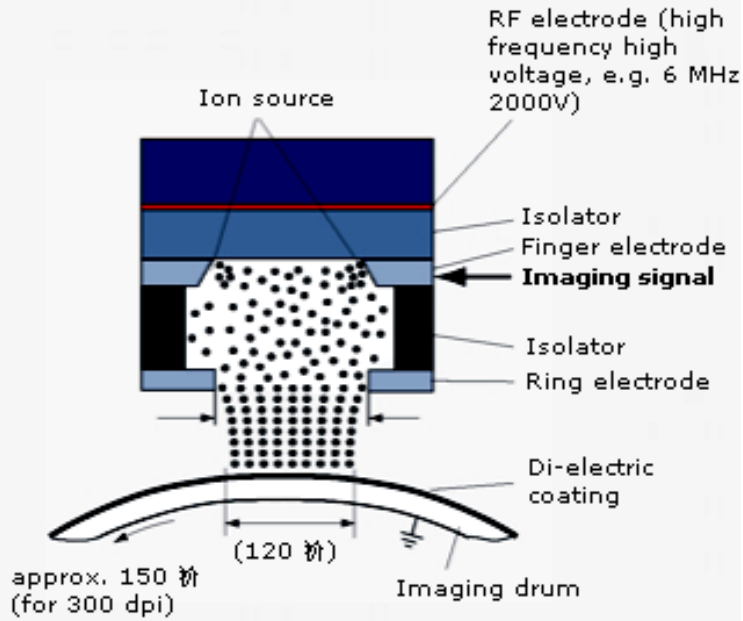
NIP Iconography

- Introduction
- Systems

Introduction



Schematic drawing of the printing process based on ionography



Diagrammatic view of the imaging process

Printing system based on ionography

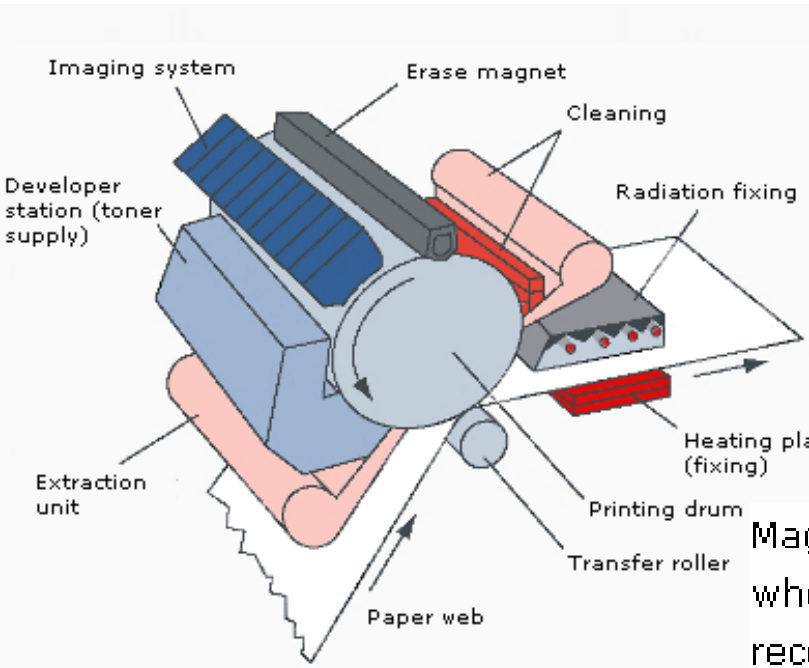
Printing unit based on ionography

This is a printing system based on ionography. This system offers a resolution of 600 dpi at a printing speed of 0.5 m per second.

NIP Magnetography

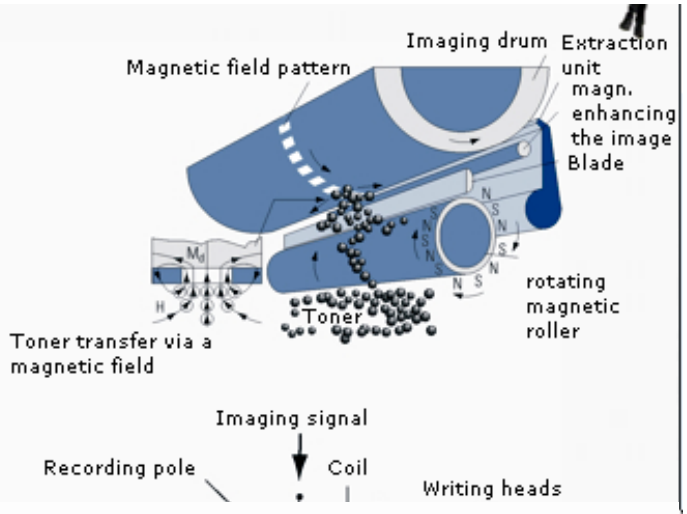
- Introduction
- Systems

Introduction



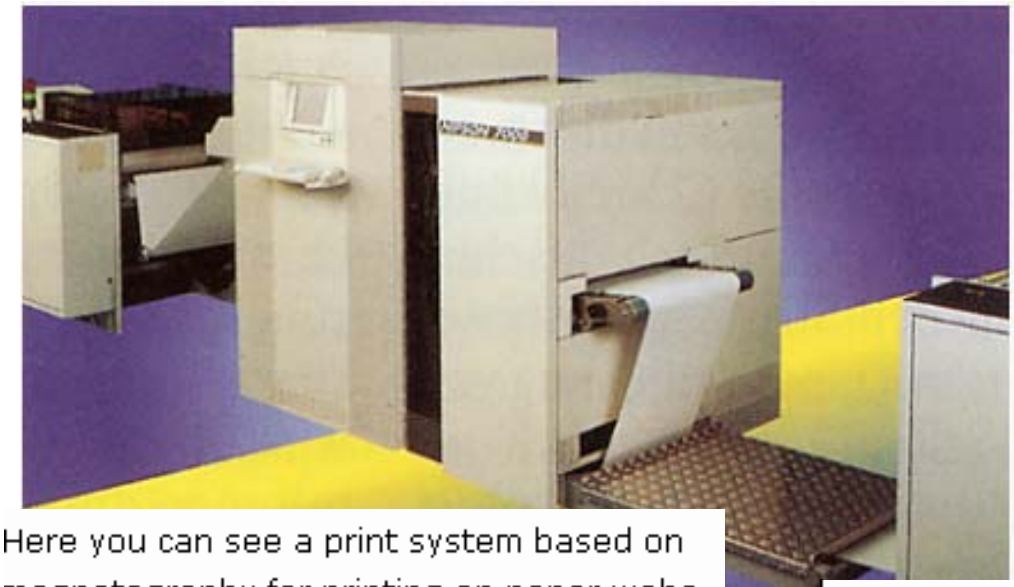
Principle of magnetography

Source: H. Ki



Magnetography is a printing technology where the electronic image is magnetically recorded on the surface of a hard metal drum. The latent magnetic image is developed with a magnetic toner and transferred onto the substrate.

Systems



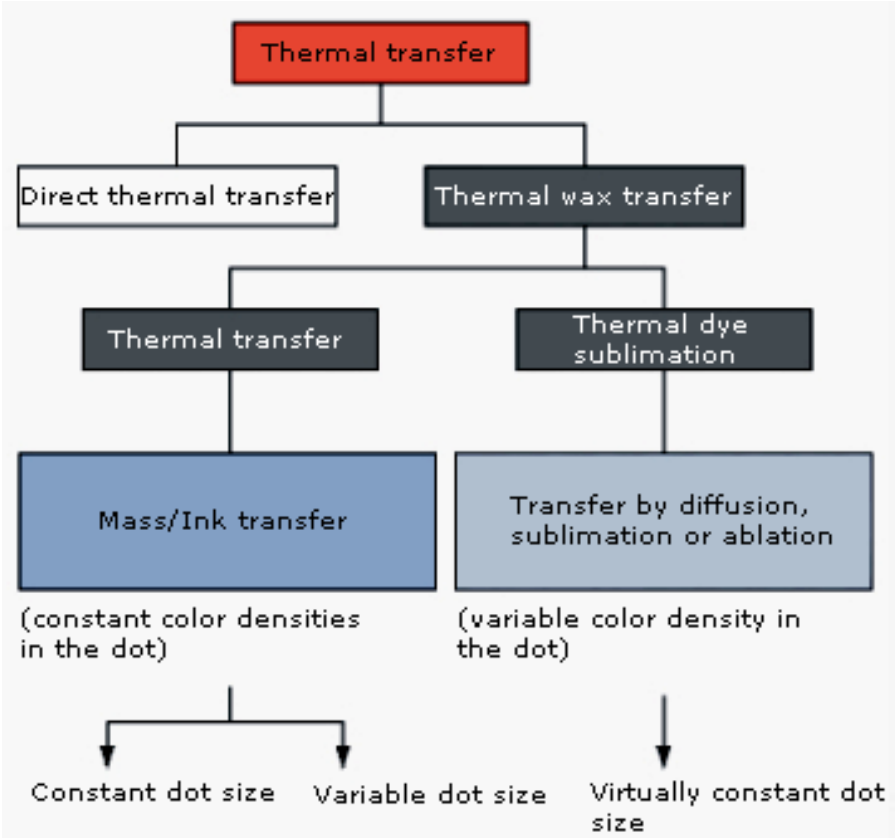
Here you can see a print system based on magnetography for printing on paper webs. The resolution is 480 dpi at a printing speed of one meter per second. The print quality achievable with magnetography does not meet the standards known from electrophotography. This is a result of the limited writing head resolution, as well as

process-related insufficiencies. These are caused by magnetic leakage fields originating from the magnetic latent image. The leakage fields always manifest themselves as poor edge definition in the print image.

NIP Thermography

- Introduction
- Print examples
- Thermal transfer
- Systems
- Thermal dye sublimation
- Systems

Introduction

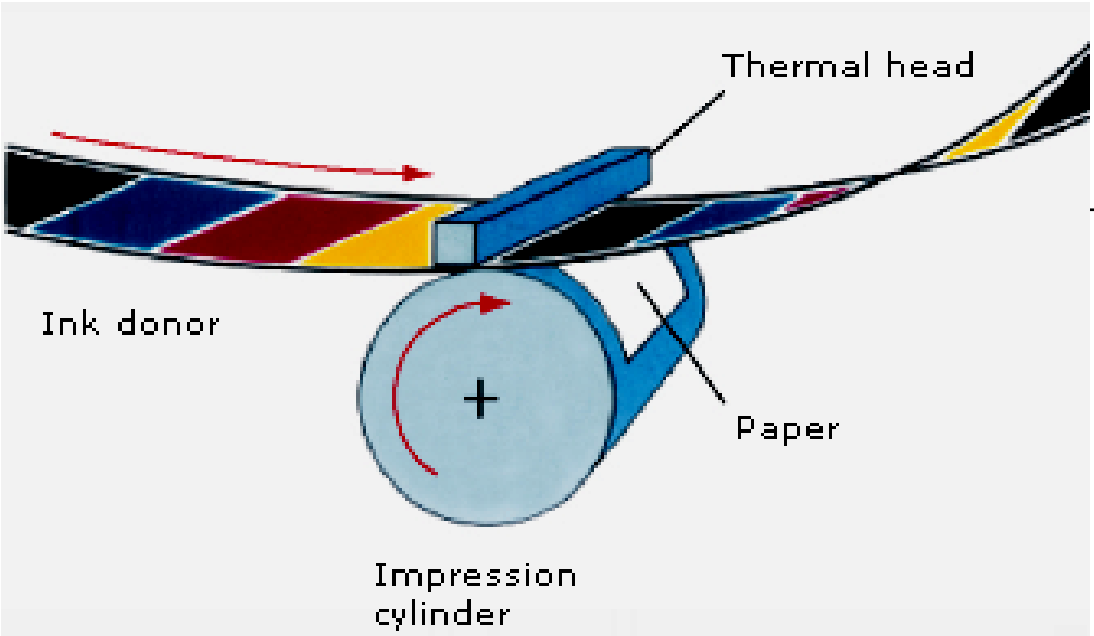


Thermal transfer printing technologies

Thermal transfer printing is based on the transfer of ink by heat application. The ink is applied to a donor - a sheet or a web - and then transferred to the substrate by the application of heat.

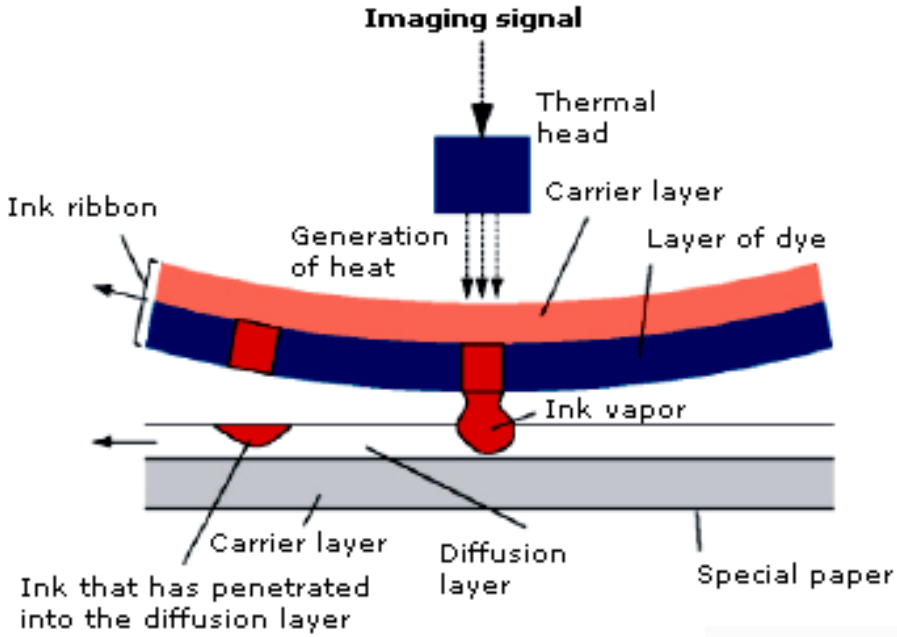
Thermofax

In direct thermal printing the substrate is treated with a special coating which changes its color when subjected to heat. One example of a well-known application is the fax machine using special fax paper.



Principle of dot generation

In thermal wax transfer printing the ink is stored on a donor and transferred to the substrate through the application of heat. During this process, part of the ink layer is released from the donor and transferred to the substrate. The ink on the donor can be wax or a special polymer.



Principle of the ink transfer

In thermal dye sublimation printing the ink is locally evaporated and depending on the thermal energy applied a certain quantity of ink is transferred to the substrate. The heat melts the ink which is then practically vaporized onto the paper. The substrate must be suited for taking up the diffused pigments. The diffusion enables variable color densities in the dot.

Print examples

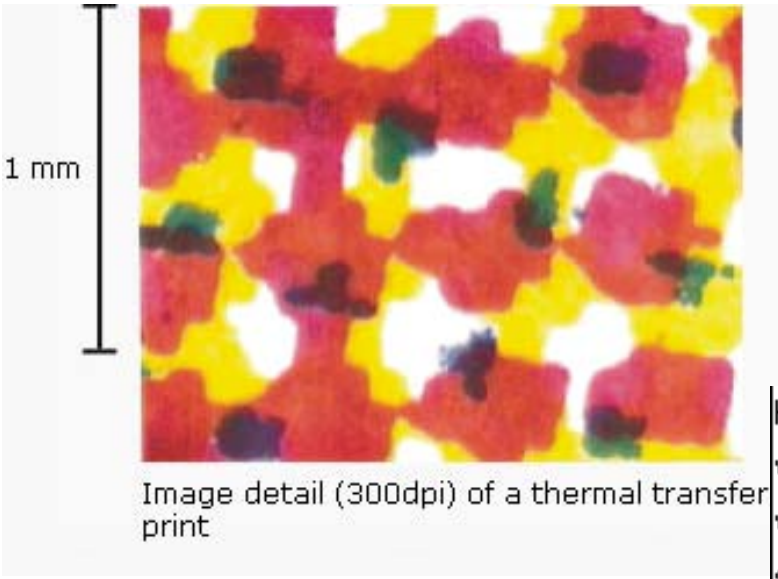
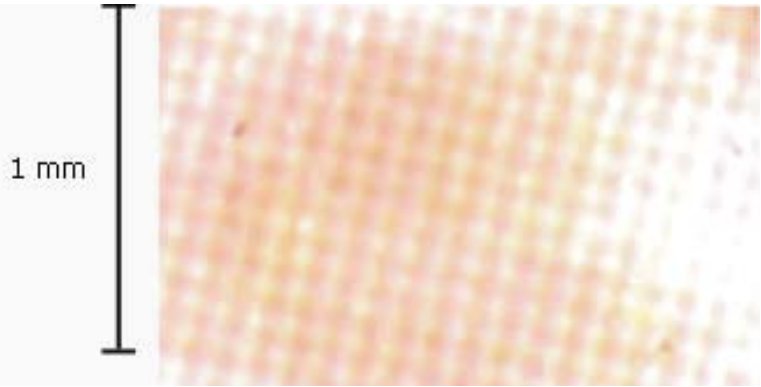


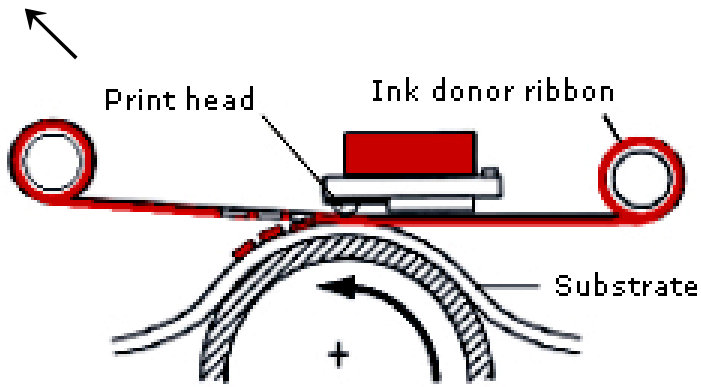
Image detail (300dpi) of a thermal transfer print



Here you can see two examples of a image with a resolution of 300 dpi using thermal wax transfer printing and thermal dye sublimation printing. It can be seen clearly that thermal dye sublimation is in a position to generate different gray values per dot of the same size. This means that with the same resolution, a higher optical quality can be achieved than in thermal wax transfer printing.

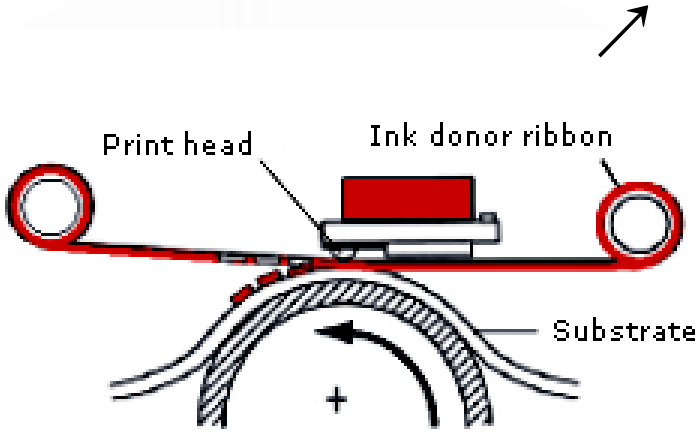
Thermal transfer

The print head heats up the ink donor and melts the ink. Older print heads are only able to produce the same dot size applying a constant quantity of heat. Newer print heads can dose the heat supply and thereby make it possible to transfer various quantities of ink by defined melting. This results in variable dot sizes on the substrate.



Configuration example of the transfer system

Through the application of slight pressure by the print head, the donor ribbon transfers the ink onto the substrate. The thickness of the ink layer, the concentration of colorant and the hue on the paper are defined by the ribbon.



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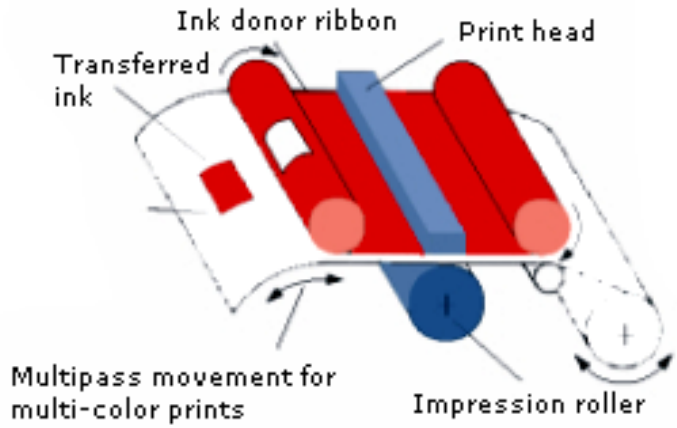
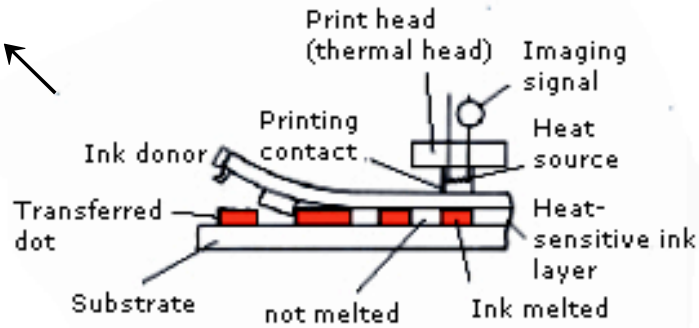


Thermal transfer for printing with a page-wide imaging unit

The ink donors typically have a total thickness of 10 ㎛, the ink layer itself is around 3 ㎛ and the protective layer 2 ㎛ thick. The protective layer ensures good heat transfer to the print head and better handling of the thin material. The ink donors are available as sheet or web material.



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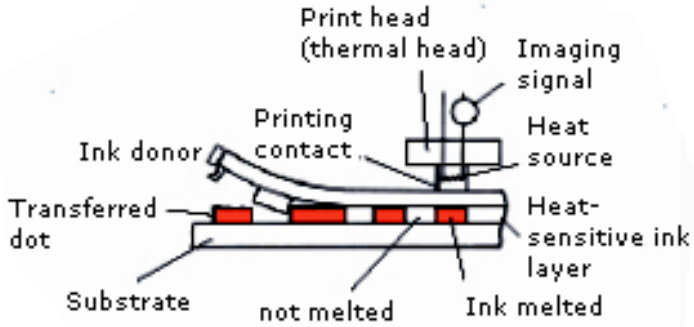


Principle of the ink transfer

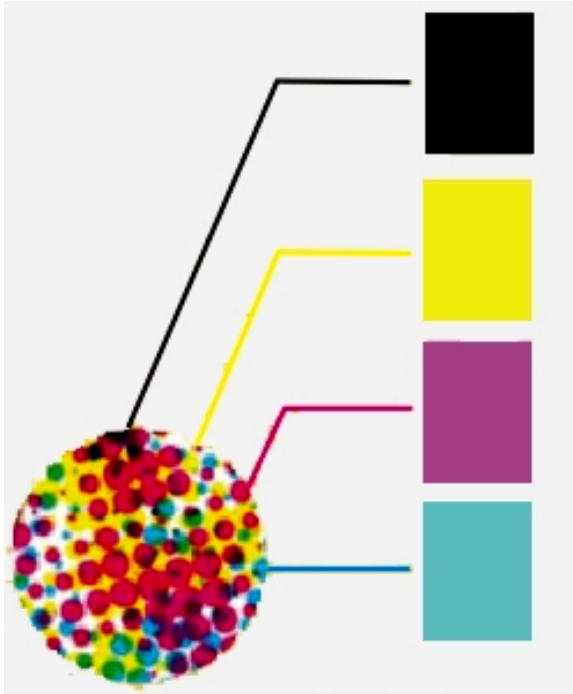
Systems

Digital multi-color press by Datametrics

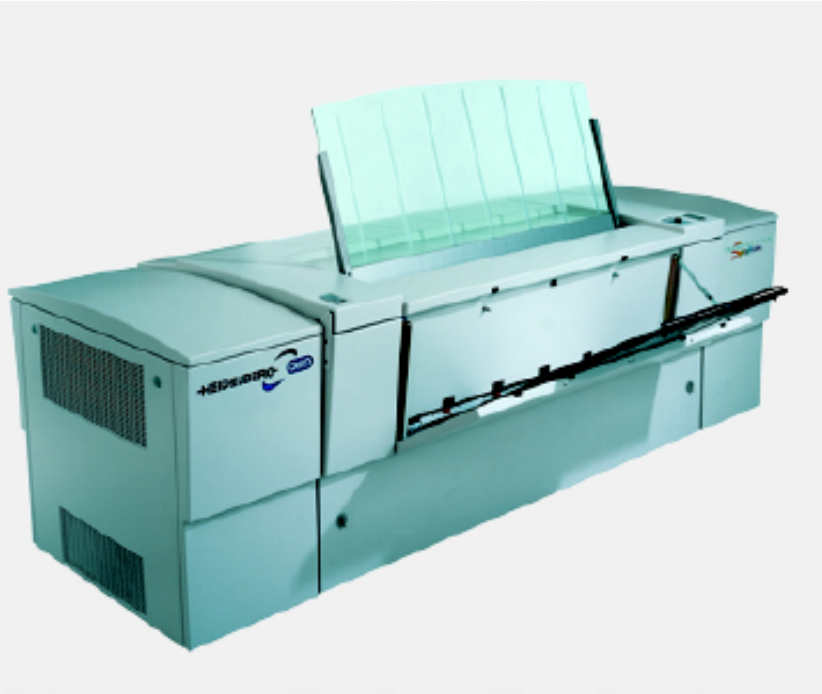
This digital multi-color printing system in unit design is based on the thermal transfer technology. It caters for printing speeds of up to 20 DIN A4 pages per minute at A3 and a resolution of 300 dpi.

Thermal transfer (MSP 36 Matan)

Here you can see a digital printing system for large-format multi-color printing. It features unit design and caters for printing speeds of up to 1m per minute at 900 mm substrate width and a resolution of 400 dpi.



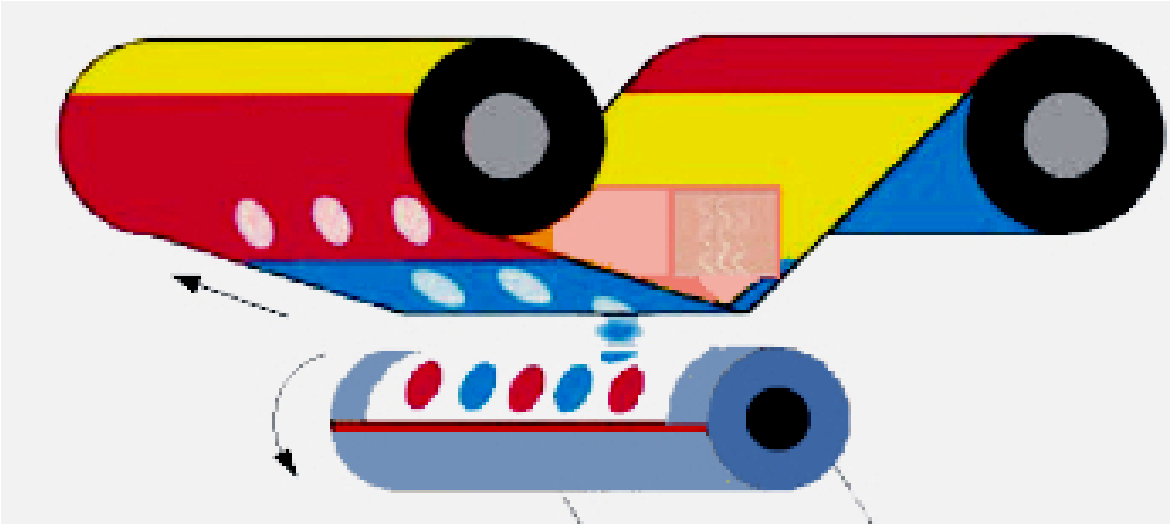
Raster structure with 4 color separations



Trendsetter proof system (resolution of up to 3200 dpi)

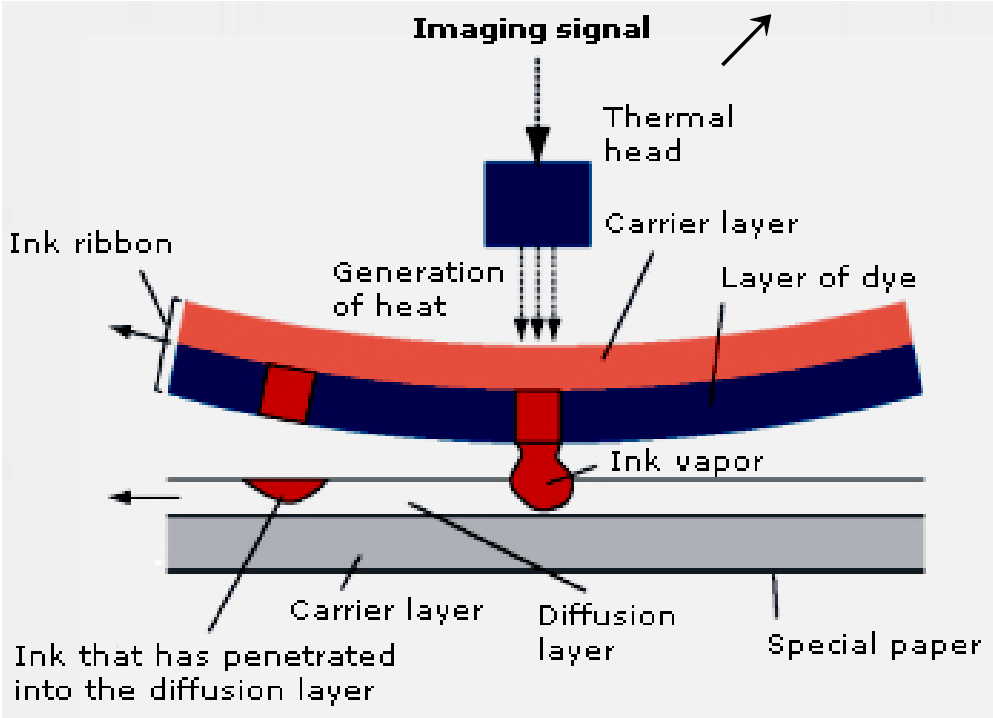
This is a thermal transfer proof system for multi-color halftone proof printing at a resolution of up to 3200 dpi. The system takes 20 minutes to print four colors in A1 format.

Thermal dye sublimation



In the thermal dye sublimation process, the ink is evaporated and the vapor enriched with pigments, penetrates the substrate.

The thermal head converts the image signal into a heating signal. One way thermal heads can produce heating signals is by laser radiation. The color density of the dot is altered by the temperature and the duration of the heating signal. Thus the quantity of heat determines the quantity of ink that is transferred.



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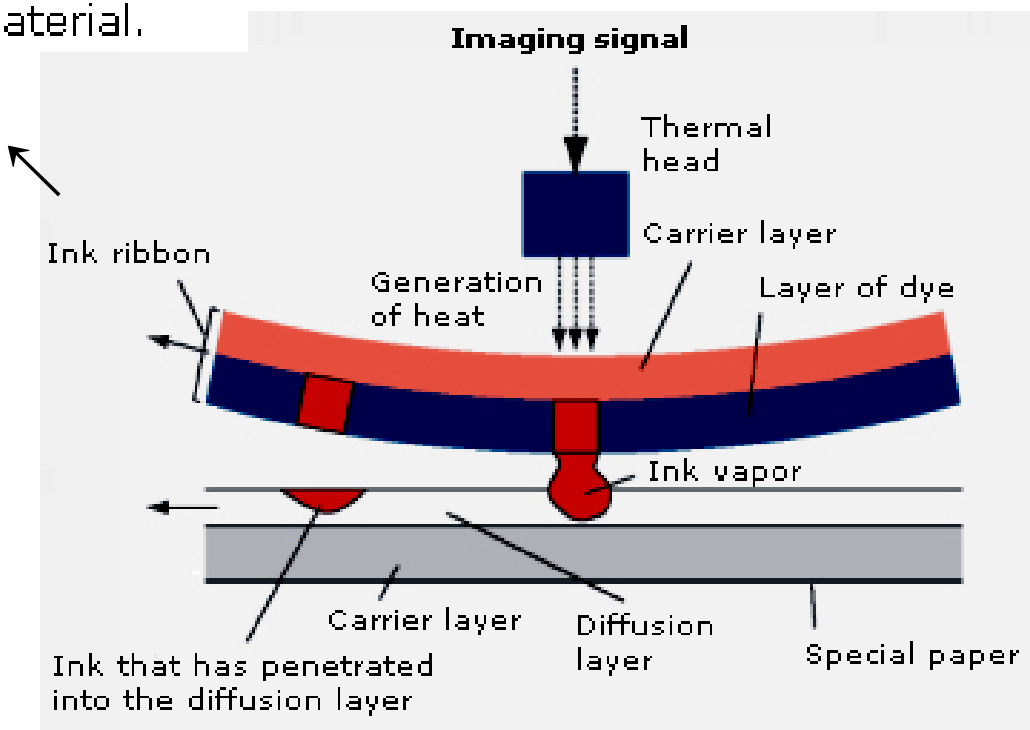
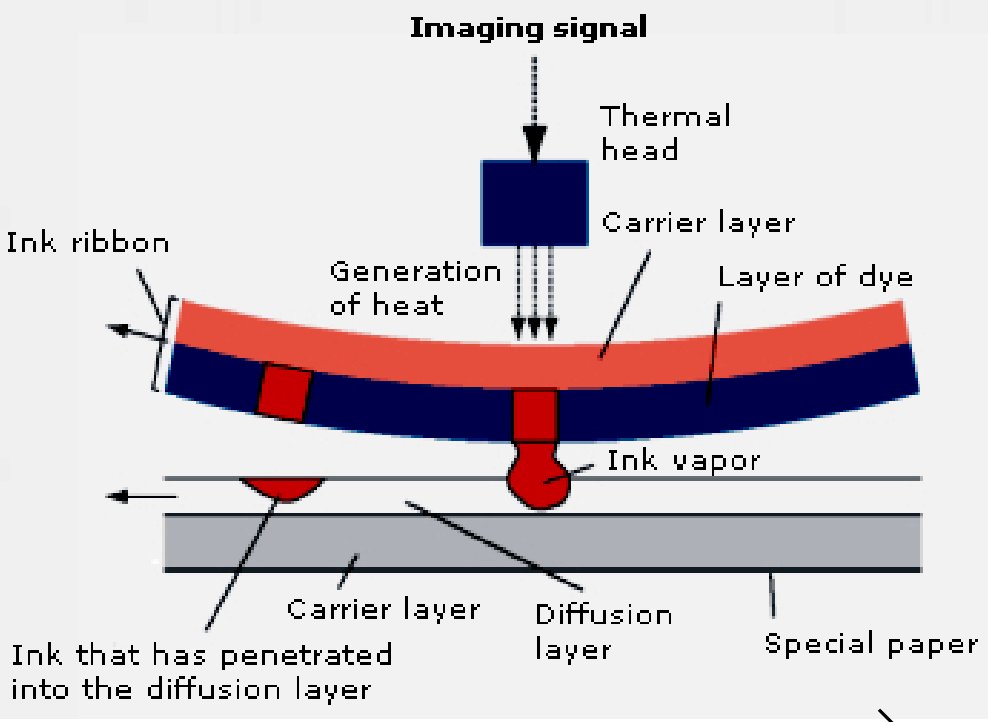
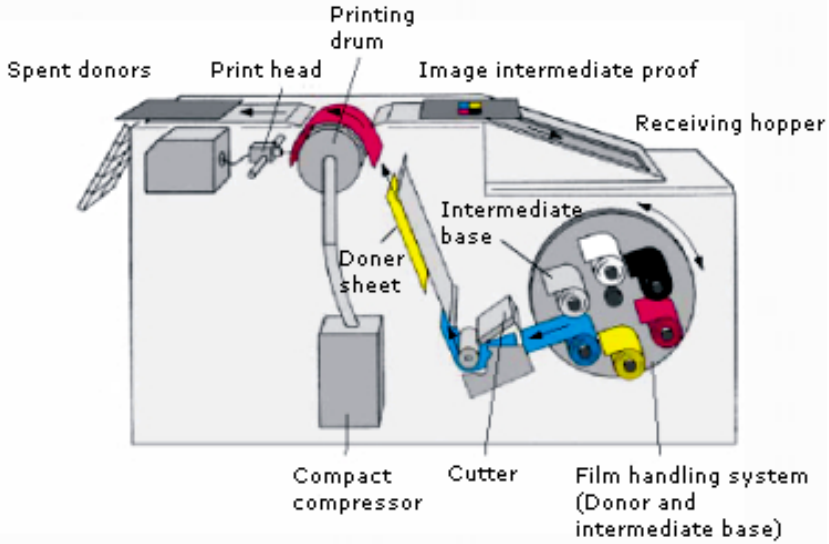




The thermal dye sublimation process requires a substrate that is treated with a special coating into which the ink can penetrate by diffusion. According to the quantity of ink entering the substrate, several gray values can be reproduced per dot. The diameter of the dots remains roughly the same although the ink density changes.

Systems

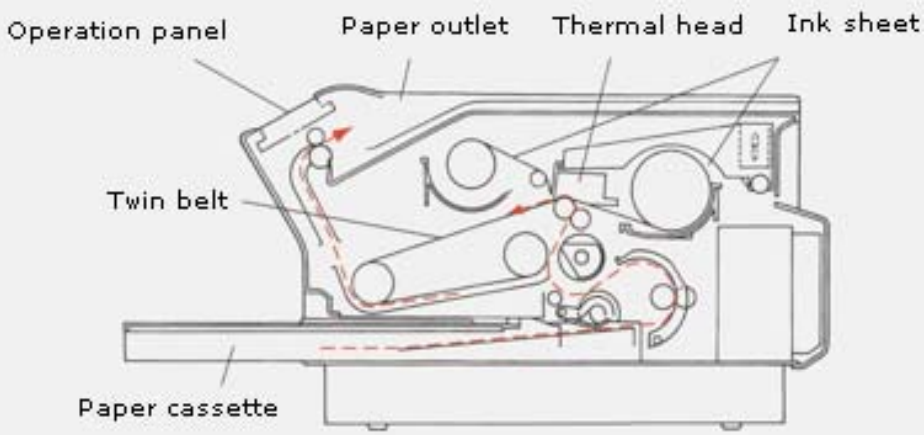
Digital color proof system (Approval, Kodak)



Functioning principle of the Approval system

Here you can see a digital color proof system based on the thermal dye sublimation principle. It can print sheet sizes of up to A3+ at a resolution of 1800 dpi.

Thermal transfer printing system



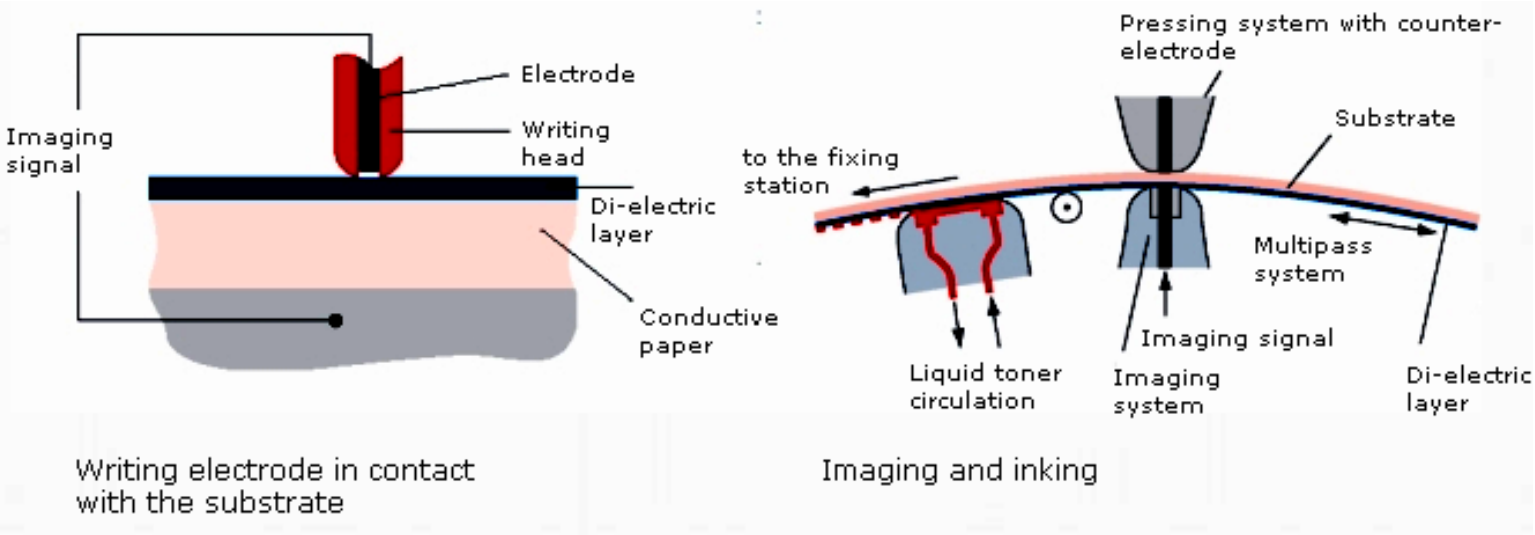
Functioning principle of the thermal transfer printing system

This digital color proof system is based on thermal dye sublimation. It can print sheet sizes of up to A3 at a resolution of 300 dpi. A print-out of this size takes around 3 minutes.

NIP Electrography

- Introduction
- Systems

Introduction



Unlike electrophotography, electrography uses an electric field to transfer the image information onto the substrate. This printing process requires a special paper with a dielectric coating.

Systems

Electrographic printing system
Xerox 8954

Here you can see an electrographic printing system for large-format multi-color printing. The printing width is 1330 mm. The system prints at a speed of 0.08 m per second and provides a resolution of 400 dpi.

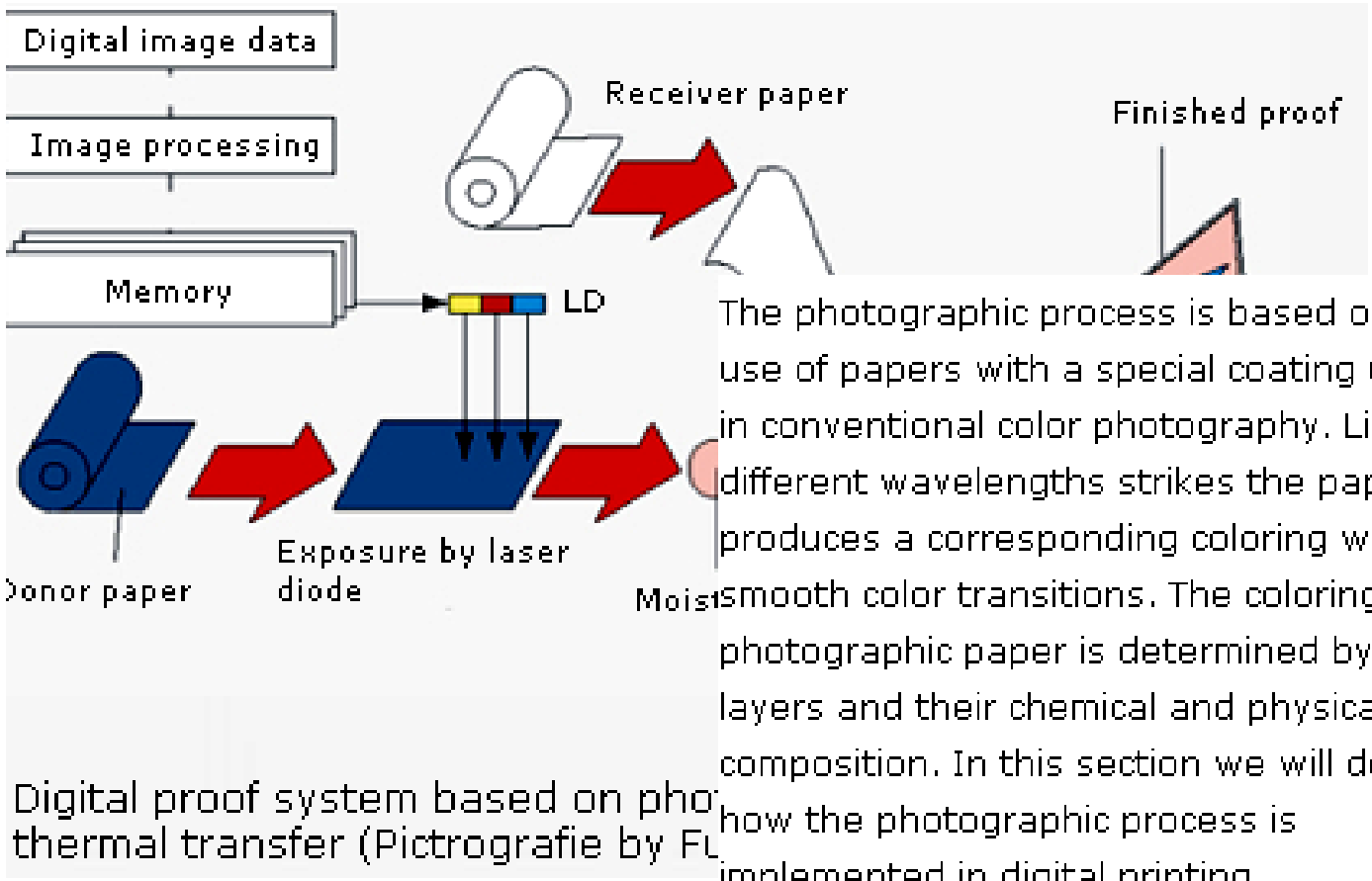
Digital ColorStation 5442 (Raster Graphics)

This electrographic printing system for large-format multi-color printing is suitable for process colors as well as additional special inks or varnishes. The printing width is 1330 mm. The system prints at a speed of 0.2 m per second and produces a resolution of 400 dpi.

NIP Photography

- Introduction
- Systems

Introduction

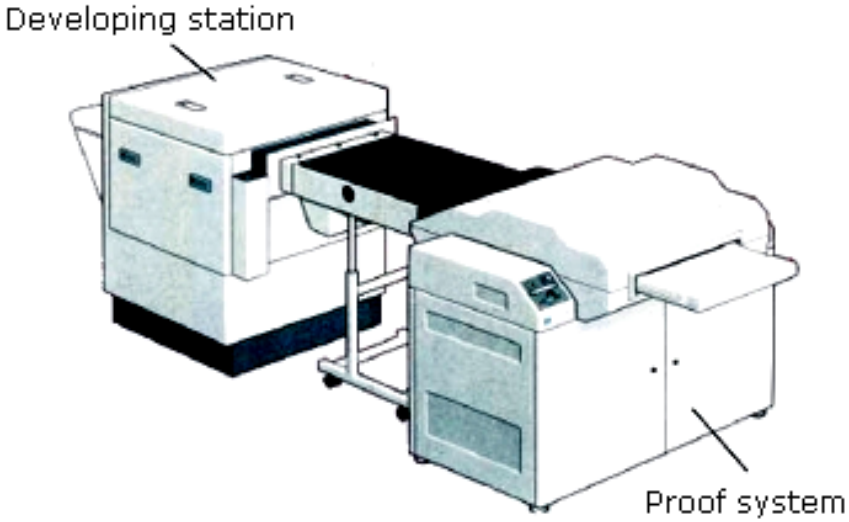


The photographic process is based on the use of papers with a special coating utilized in conventional color photography. Light with different wavelengths strikes the paper and produces a corresponding coloring with smooth color transitions. The coloring of the photographic paper is determined by several layers and their chemical and physical composition. In this section we will detail how the photographic process is implemented in digital printing.

Pictoproof (400dpi)

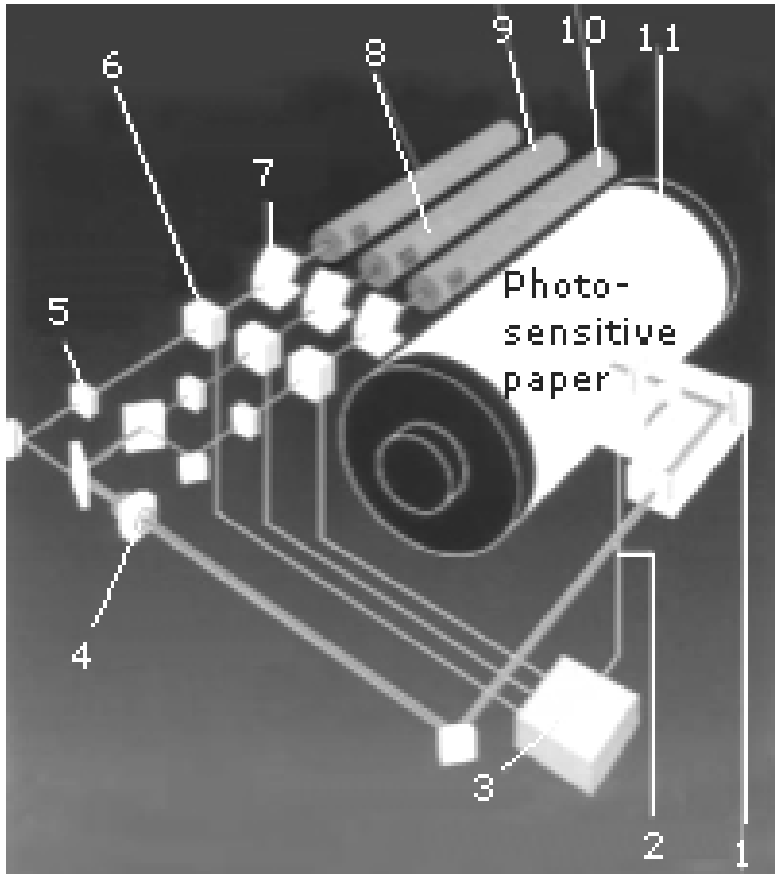
This is a digital proof system based on photography and thermal transfer printing. The imaging information is transferred via a transfer sheet.

Systems



Proof system with developer station

Here you can see a proof system that uses lasers for imaging based on the external drum principle. The resolution may reach 4000 dpi and the maximum sheet size is A2+.



Imaging based on the external drum technique

The imaging data are processed and then exposed on photosensitive paper via three lasers in the primary colors of red, green and blue. The intensity of the lasers determines the desired hue in the image. The resolution achieved with this type of exposure can be very high.

1 Moveable carriage
2 Closed loop feedback
4 Beam controller
4 RGB laser beams
5 Beam configuring optics
6 Beam modulator
7 Intensity control
8 Blue argon-ion laser
9 Red helium neon laser
10 Green helium neon laser
11 Imagesetter drum

NIP Comparison of printing processes

	Speed	Quality	Costs per print
Inkjet (Drop on demand)	low	high	medium
Inkjet (continuous)	high	low	low
Electrophotography	medium		
Ionography	medium		
Magnetography (monocolor only)	high		
Thermal transfer	medium		
Thermal dye sublimation	low		
Electrography	low		
Photography	low		

It is very difficult to compare the different technologies with each other, since they progress very rapidly and each technology has its specific properties, advantages and disadvantages. Inkjet, thermal sublimation and photography are better suited for individual high-quality prints, whereas the other printing technologies are cost-efficient even for longer print runs of up to 2,000 copies.

Comparison of printing technologies

- Introduction
- Technologies & Products
- Print qualities

Introduction

Speedmaster 74 DI

NexPress 2100

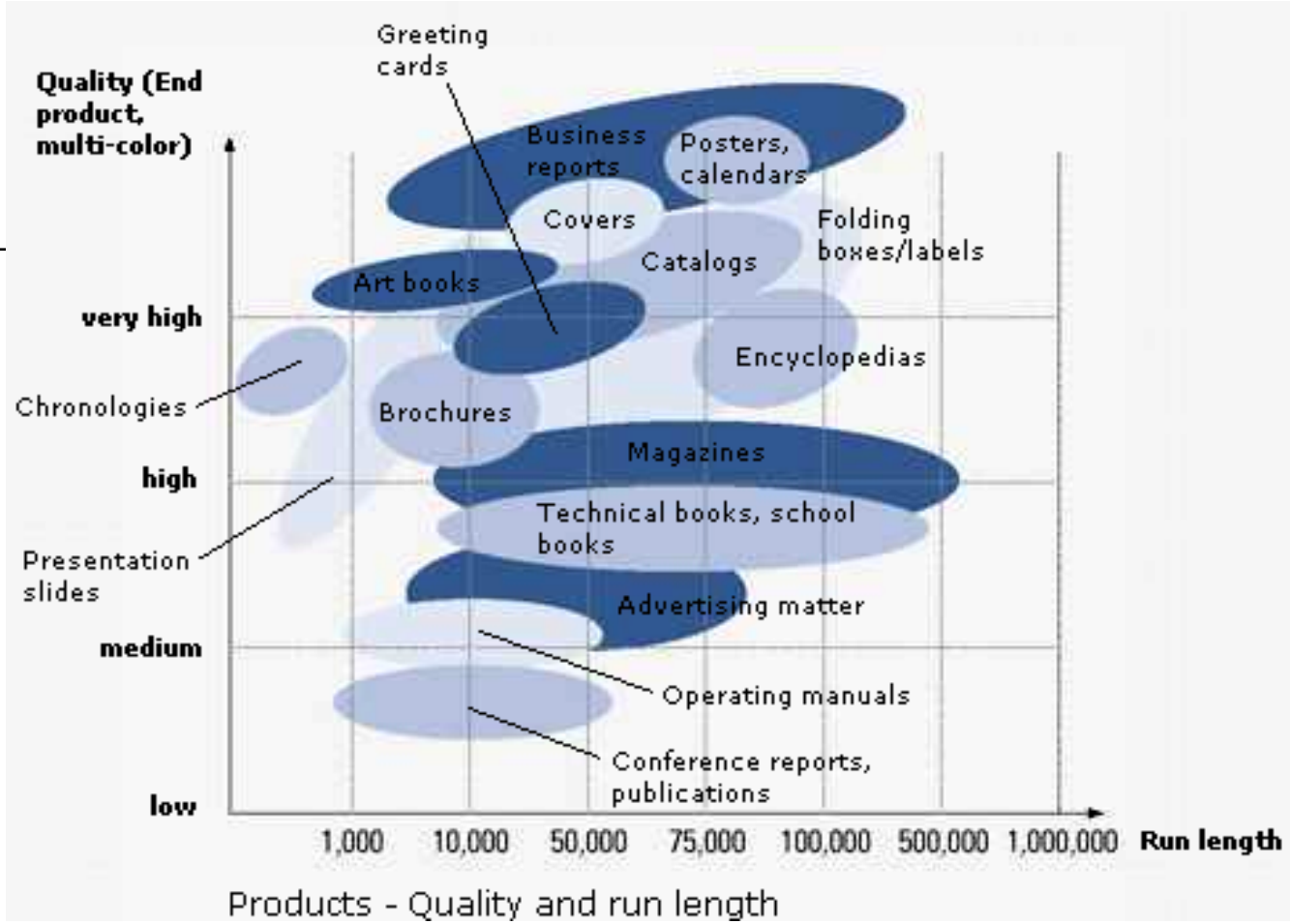
Semi-automatic screen printing machine

Each printing technology has its own individual characteristics. Under certain circumstances such as for very long print runs, digital printing is not be economical whereas gravure printing would be unviable for short run lengths. Not every substrate can be printed with every printing technology. Have a look at the overview of possible printing technologies.

Technologies & Products

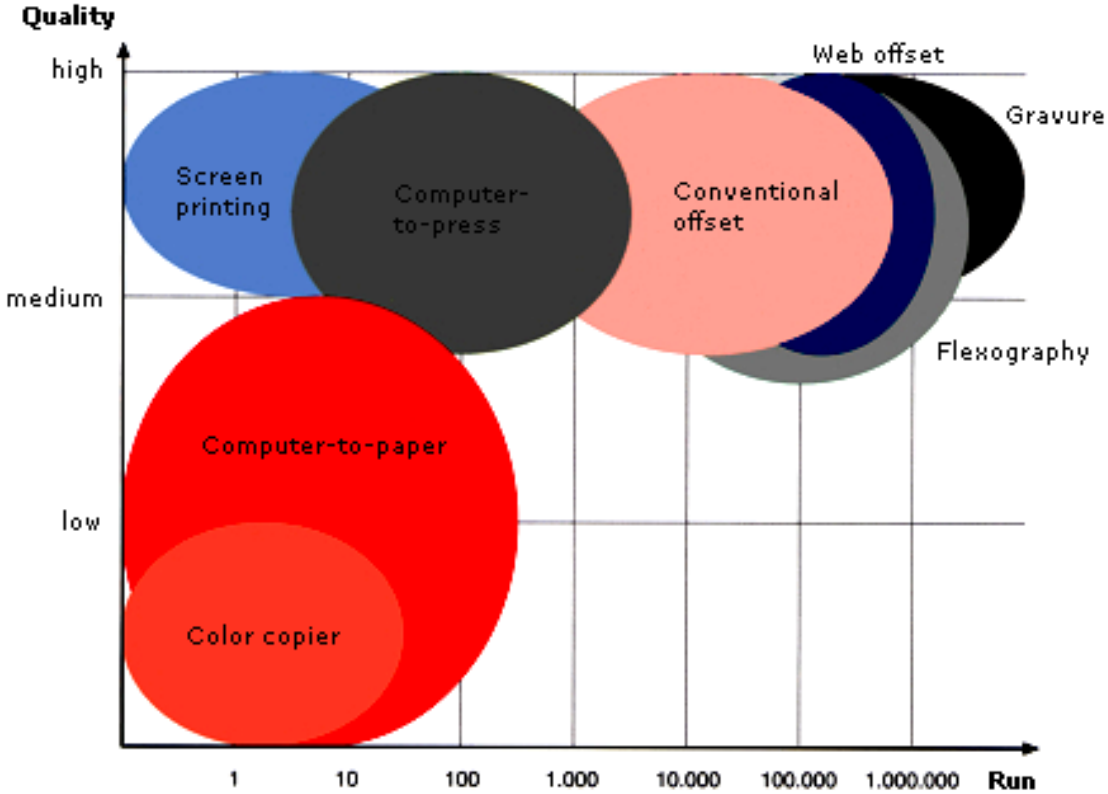
Printing technologies	Products	Run length approx.
Relief printing		
Letterpress	Business cards, imprints, family printed matters punching, embossing, perforating, numbering	Short 15,000 up to 350,000
Flexography	Unit form sets and continuous form sets, packaging material, plastic foils, labels	All
Screen printing		
Screen printing	Glass, textiles, metals, wood, foils, plastic, board, paper, card	< 1,000
Gravure printing		
Illustration printing	Advertising matter (long run range), mail-order catalogs, magazines (large circulation)	> 250,000
Decorative printing	Veneer, wallpaper	Web
Lithography		
Sheet offset	Labels,books, magazines, unit form sets, advertising matter catalogs, calendar, art prints, posters, folding boxes, books	Short to medium
Web offset	Magazines, inserts, newspapers, advertising matter, catalogs, books	30,000 up to 1 mill.
DI technology	All kinds of sheet offset products i	
Digital printing		
Inkjet process	Proof prints, posters (plotter), diffe	
Electrophotography	Personalized print products	

This is a list of printing processes and the types of products and run lengths produced with these technologies.



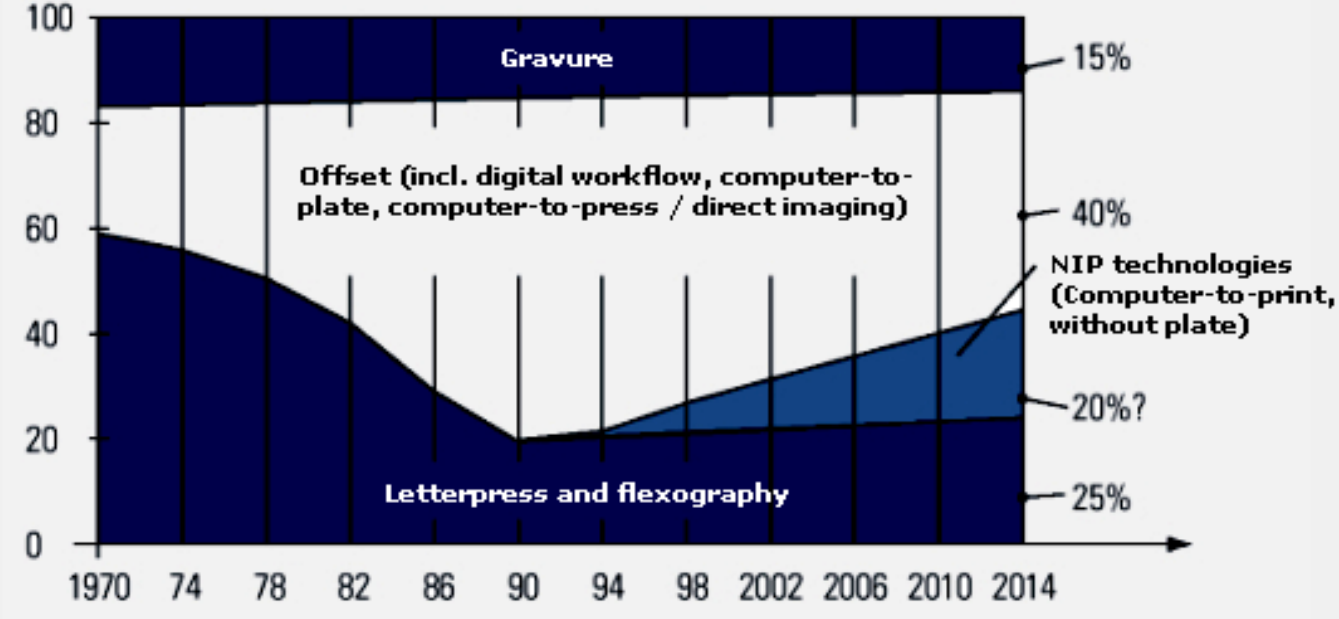
Products - Quality and run length

The following two representations demonstrate how quality is dependent on run length. The first diagram shows this on the basis of product groups ...



Printing technologies - Quality and run length

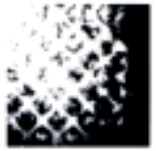
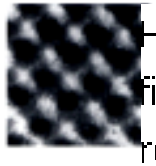
... while the second shows it on the basis of printing technologies..



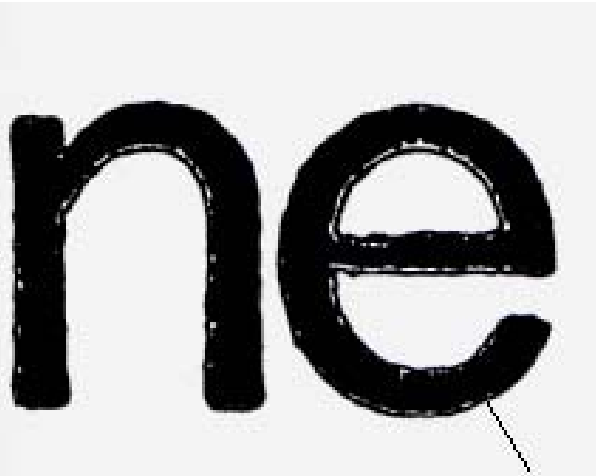
Market share under the aspect of value of products sold

These are the market shares of the various printing technologies and what they will probably be like in the near future.

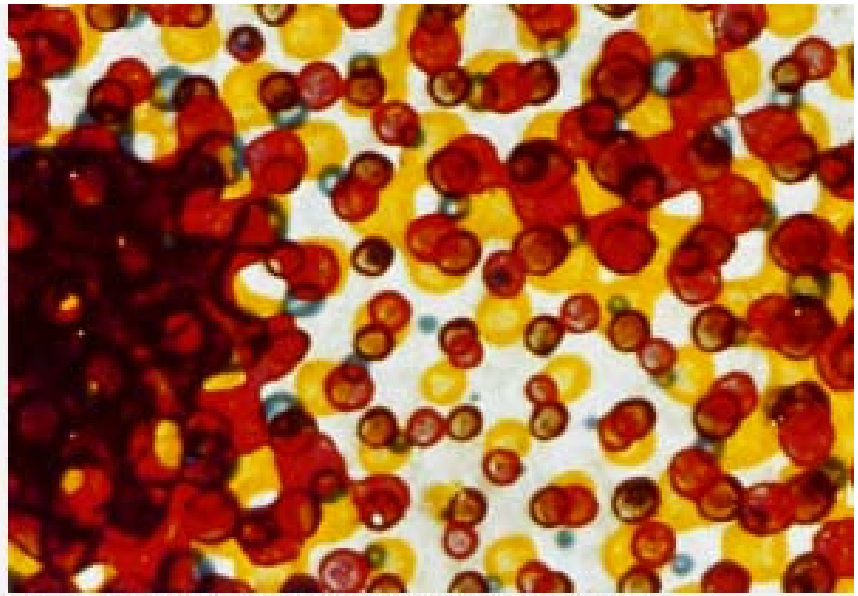
Printing qualities

Printing technologies	Text	Halftone dot
Halo effect on letters	ne	
Screen printing	ne	
Gravure printing	sc	
Lithography	na	
Electrophotography	n	

Here you can see a direct comparison of the five most common printing technologies regarding their print quality.



Halo effect on letters



Halftone dots in letterpress printing

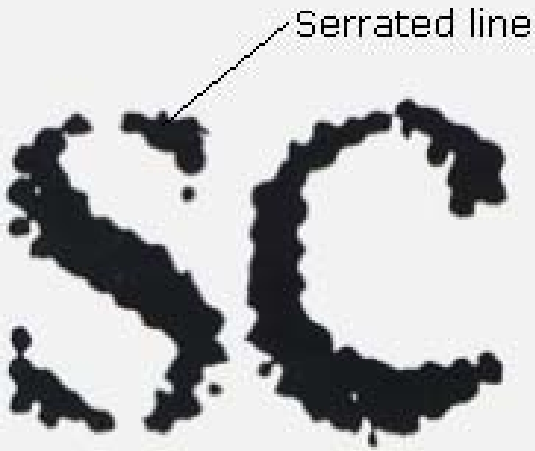
Letterpress printing causes a halo effect at the edges of printed letters.

Print quality of screen printing

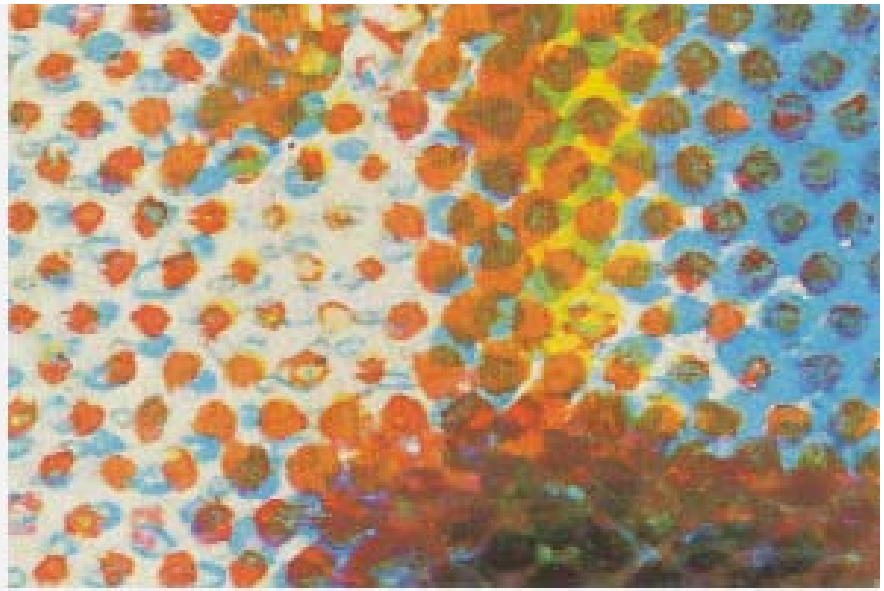
Halftone dots in screen printing

Source: H. Kipphan

In screen printing it is possible to print very thick ink layers. They can be up to 20 times thicker than in all other printing technologies.

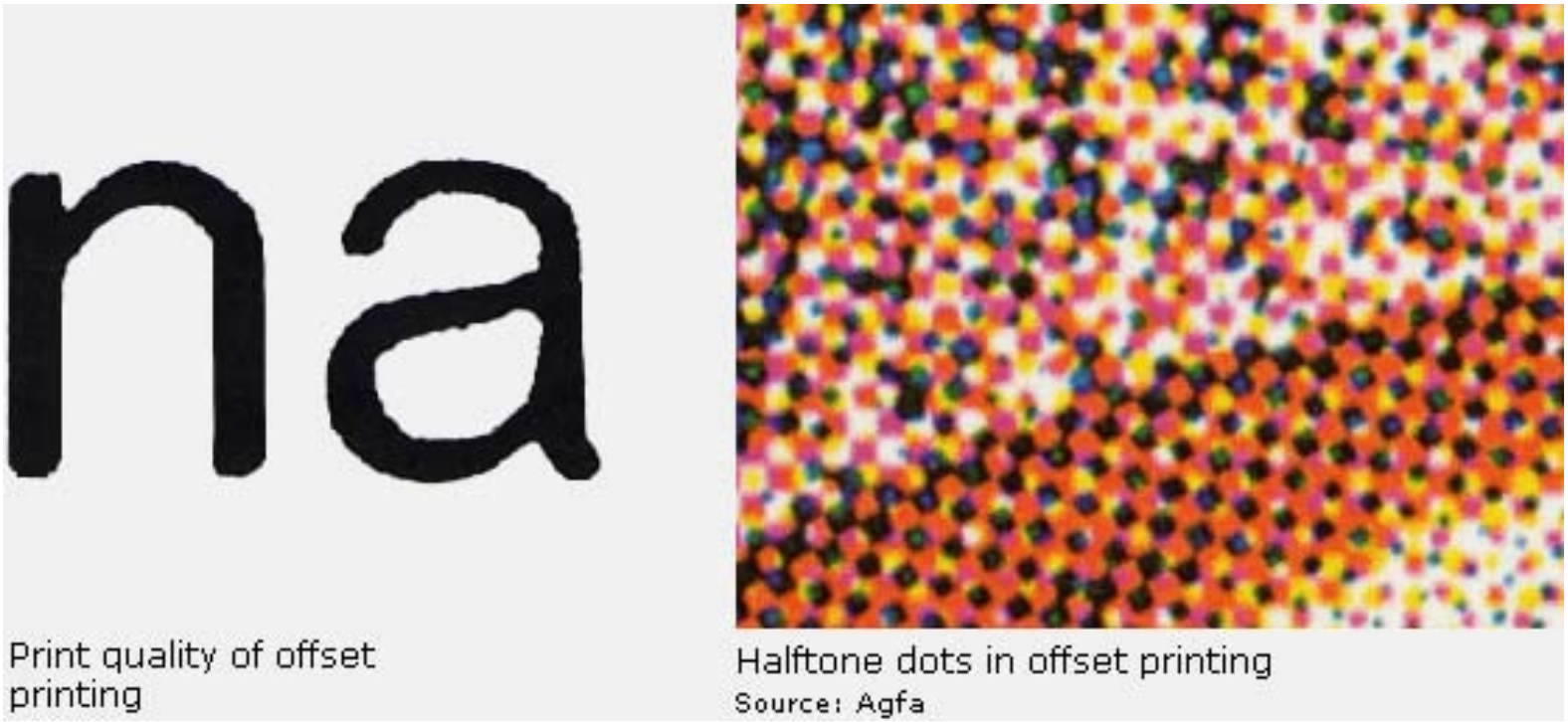


Print quality of gravure printing



Halftone dots in gravure printing
Source: BASF

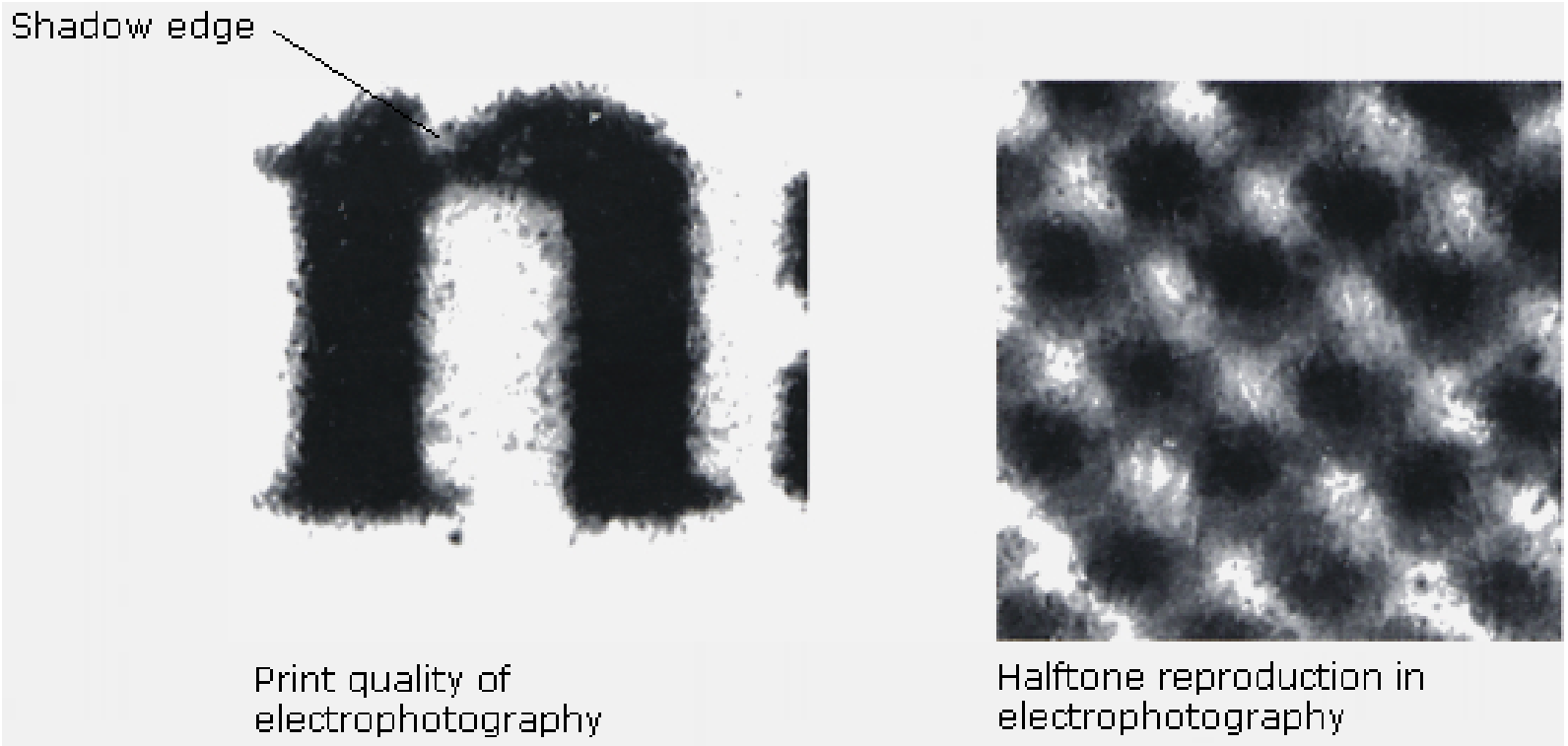
A characteristic of gravure printing is the serrated line on the gravure cylinder caused by the engraved cells. When printing letters these serrated lines are clearly recognizable. The printing quality achieved with gravure printing is excellent, since real continuous tones can be reproduced with this technology.



Print quality of offset printing

Halftone dots in offset printing
Source: Agfa

When printing letters, lithographic printing provides a clean printed image without halo effect and serrated lines.



Print quality of electrophotography

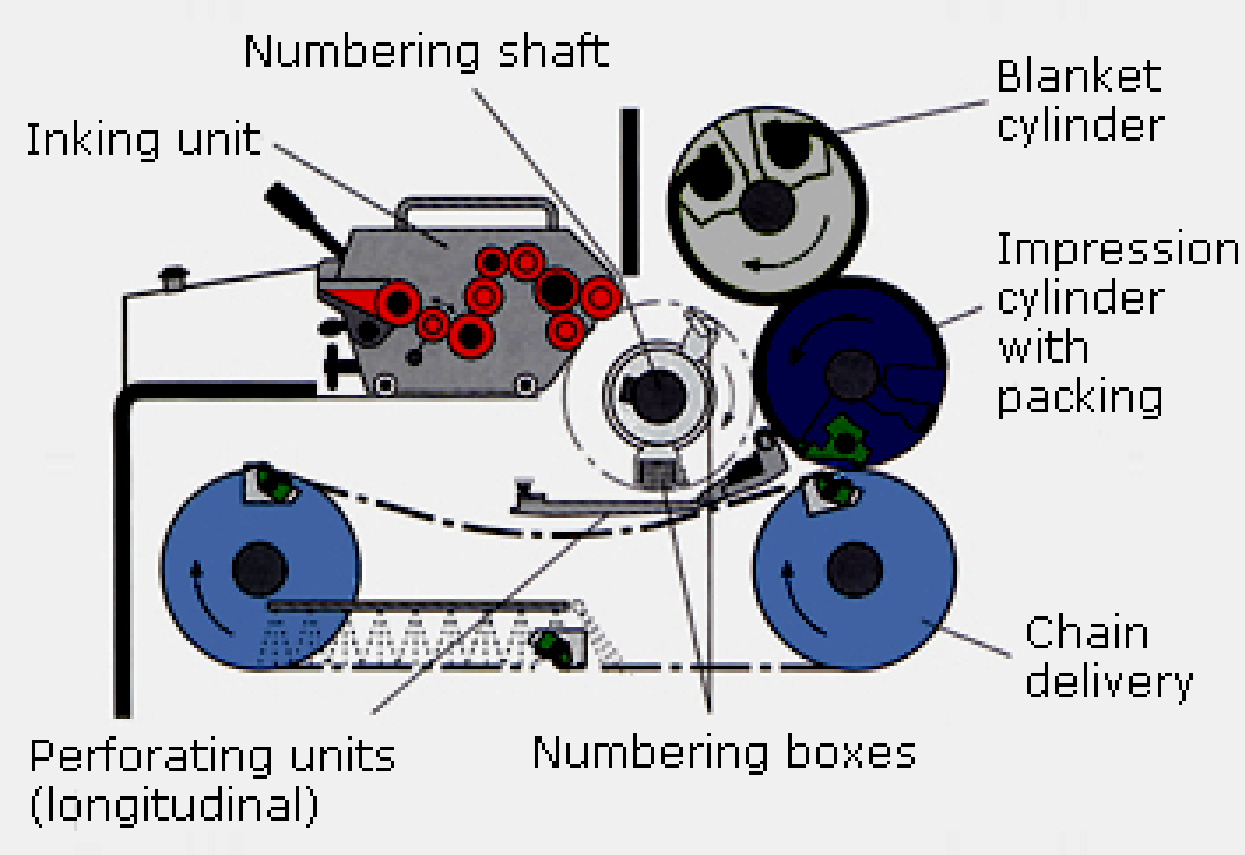
Halftone reproduction in electrophotography

As a result of scattering during the electrostatic charge of the substrate, electrophotography produces a shadow around the edge of letters.

Inline finishing

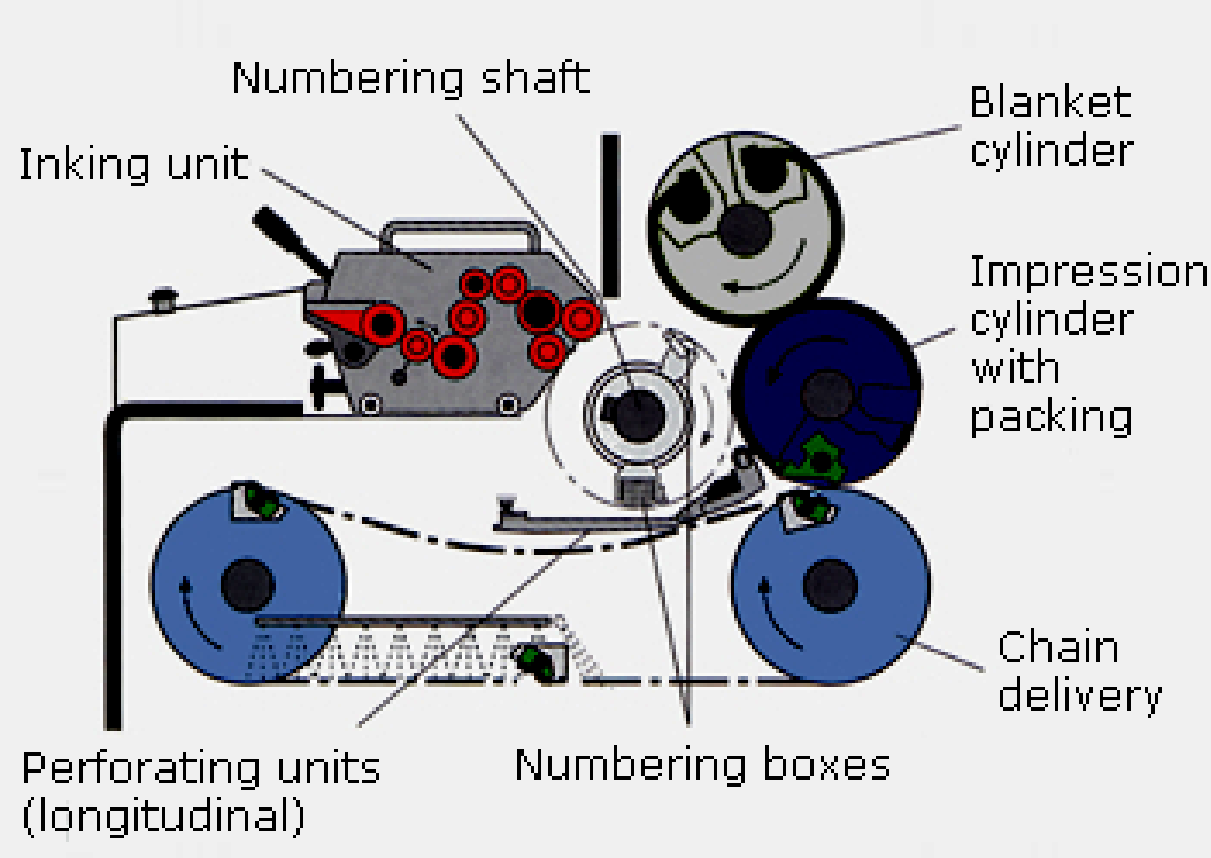
- Numbering
- Perforating

Numbering


Numbering shaft
Inking unit
Blanket cylinder
Impression cylinder with packing
Chain delivery
Perforating units (longitudinal)
Numbering boxes

Numbering with letterpress printing

Perforating

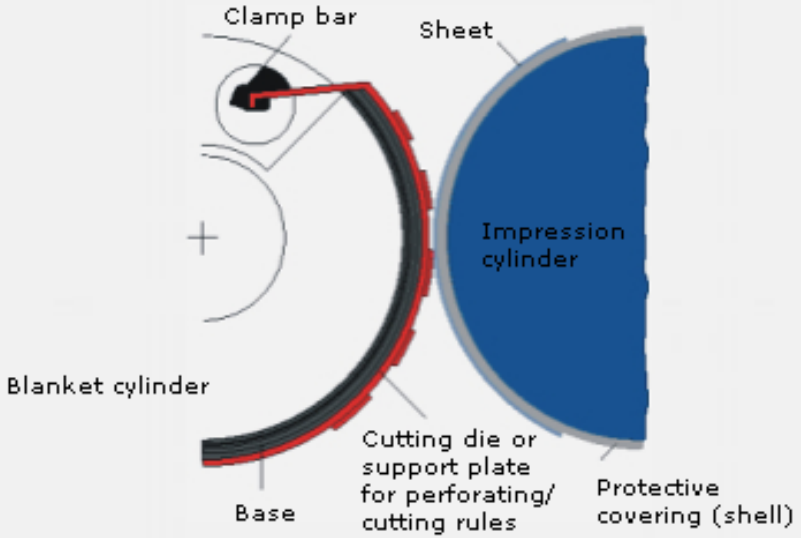


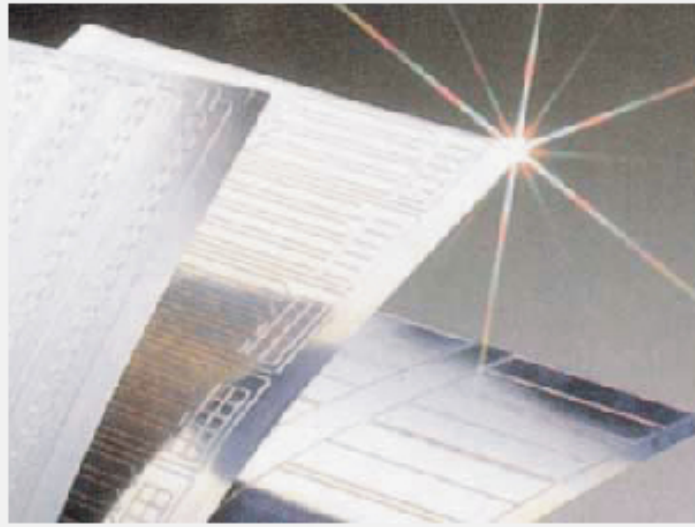
Perforating unit in operation (after printing)

Perforating tool - parallel to the cylinder shaft

Perforating tool - along the cylinder circumference

These are perforating tools which are mounted in the press. The perforating knife is pressed through the material; this produces a tear-off line. The slitting wheels of the perforating unit touch the sheet on the impression cylinder. Because of this, the impression cylinder must be provided with a special protective covering.





Cutting dies

There are also cutting and perforating dies that are attached to the blanket cylinder. In this way self-adhesive labels and decals can be cut directly in the press. The respective counter cylinder must be fitted with the appropriate covering.