Color, Printing, Decoration Technologies

Presented to the Activities Unlimited, Science Club
By Harry Bennett,
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Agenda

- **Color**
- **Printing & Decorating**
  - Printing Methods
  - Other Decoration Techniques
  - Printing Dimensional Packages

Introduction

- Printing and Decorating creates a visibly identifiable image for a large number of impressions
- Requires ability to separate image and non-image (text) areas
- Printing plate is used to create this separation
- Printing or Decorating methods are named after the type of printing plate

Introduction

- Techniques can be divided into 2 groups
  - **Printing** (Paper Decoration): flexography; lithography; gravure; digital
  - **Decorating**: screen printing; hot-foil stamping; embossing; pad printing

- **Color** is a key element to printing and decorating processes

Color - Electromagnetic Spectrum

- Waves at Long end = radio and radar
- Shorter infrared waves are perceived as heat
- Visible light is perceived by human eye
- Ultraviolet is a shorter wavelength and is not perceived by the human eye
- X-rays are shorter yet and can penetrate matter to be recorded on a photographic plate
- The shorter Gamma rays can disrupt molecular structure and are used to sterilize food and hospital supplies

How many colors can the Human Eye See?

- The human eye retina has receptors that are sensitive to RED, GREEN and BLUE
- The brain interprets and blends these wavelengths to create the color spectrum we actually see
- The eye can differentiate several million colors
- The brain separately determines brightness or contrast levels

+ Color

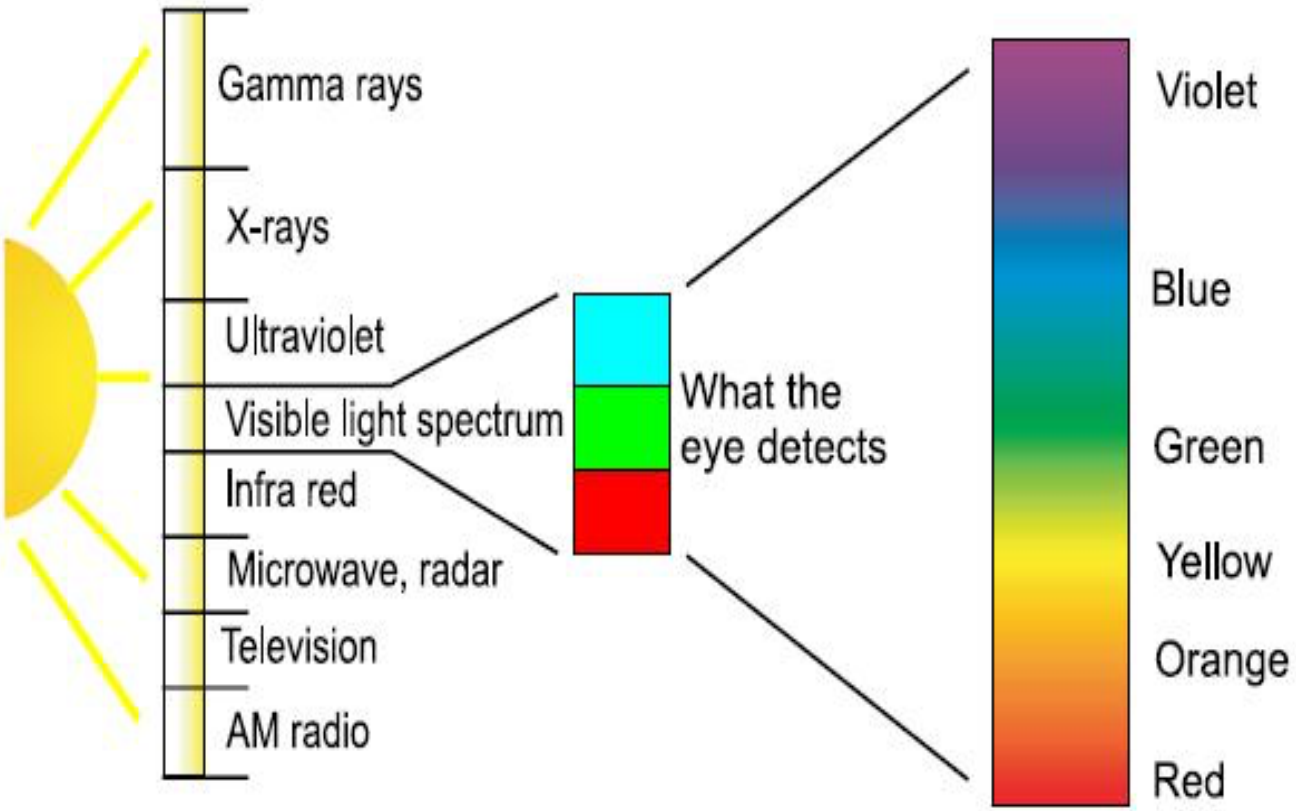


Figure 4.1

Visible light as radiated by the sun is that part of the electromagnetic spectrum between 380 and 760 nanometres (nm). The human eye can only detect red, green and blue (RGB).

Color Perception

- Human eye does not detect all colors equally
  - Sensitivity falls off at either end of the visible spectrum
  - Greatest contrast is between BLACK and YELLOW
  - Biological defects in the retina can result in various degrees of "color blindness"
- Full stimulation of all receptors is interpreted as WHITE
- No stimulation of receptors is interpreted as BLACK (which for convenience is called a color)

+ Color Perception

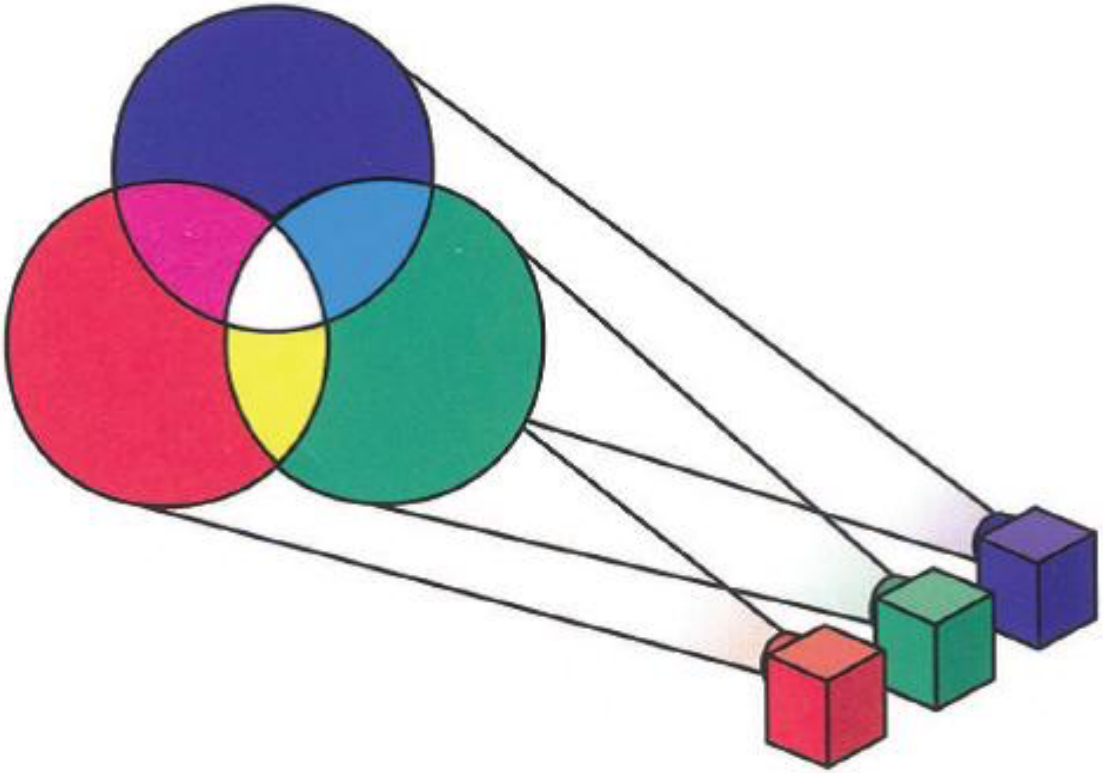


Figure 4.2

When equal proportions of red and green, red and blue, or blue and green light are perceived simultaneously, we experience yellow, magenta and cyan, respectively. When the eye receives all three colors simultaneously, we experience white.

Additive Synthesis

- **Additive Synthesis** is the combination of different wavelengths to create a new color

Primary Color Combination	Visible Result
Blue + Green	Cyan
Red + Blue	Magenta
Red + Green	Yellow

Additive (Light) Color Primaries

- **Red**, **green**, and **blue** are the primary colors of light—they can be combined in different proportions to make all other colors. For example, red light and green light added together are seen as **yellow** light.
- This additive color system is used by light sources, such as televisions and computer monitors, to create a wide range of colors.
- When different proportions of red, green, and blue light enter your eye, your brain is able to interpret the different combinations as different colors.
  - Source: Harvard Smithsonian Center for Astrophysics. This media asset was adapted from Shedding Light on Science

Subtractive (Pigment) Color Primaries

- There is another set of primary colors with which you may be more familiar. The primary colors of pigment (also known as subtractive primaries) are used when producing colors from **reflected light**
- For example, when mixing paint or using a color printer. The primary colors of pigment **are magenta**, **yellow**, and **cyan** (CMYK).
- Pigments are chemicals that absorb selective wavelengths—they prevent certain wavelengths of light from being transmitted or reflected.
- For example, **cyan paint absorbs red light** but reflects blue and green light; **yellow paint absorbs blue light** but reflects red and green light, **magenta paint absorbs green light** and reflects blue and red light)
- If cyan paint is mixed with yellow paint, you see green paint because both red and blue light are absorbed, and only green light is reflected.
  - Source: Harvard—Smithsonian Center for Astrophysics. This media asset was adapted from Shedding Light on Science

Subtractive Synthesis

- **Subtractive Synthesis** is the effect of printing inks (& paint) where colors are produced by subtracting wavelengths from WHITE light

Colors produced by subtraction from WHITE light		
Absorbs	**Reflects**	**Color Seen**
Red	Blue and green	Cyan
Blue	Red and green	Yellow
Green	Blue and red	Magenta
All wavelengths	Nothing	Black

Subtractive Synthesis

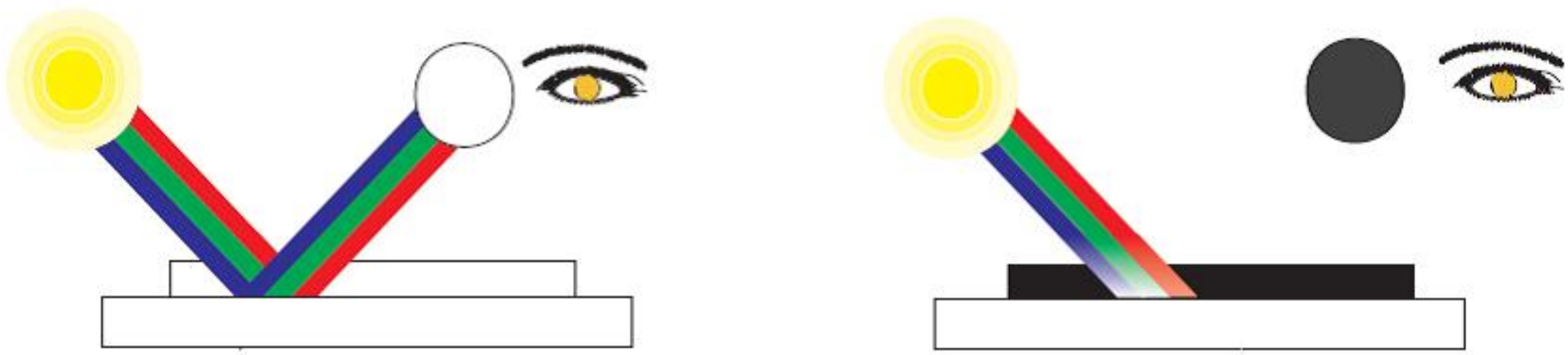


Figure 4.4
When all components of white light are reflected, the object appears white. If all light components are absorbed by the object, no light is reflected and the object is perceived as being black, black being the absence of light.

Subtractive Synthesis

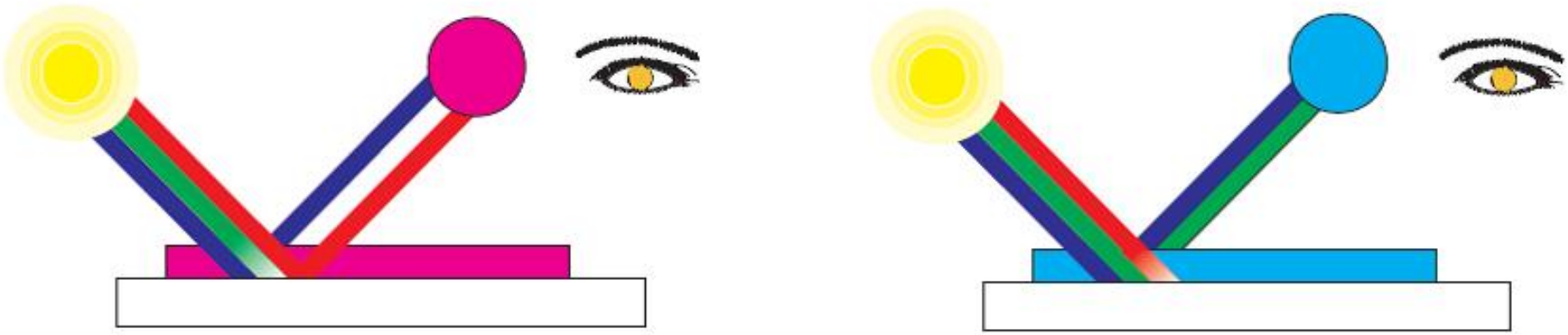


Figure 4.5
When the green component of white light is absorbed by a printing ink, the reflected blue and red components are perceived as magenta. Similarly, when the red component is absorbed, the eye perceives cyan.

Subtractive Synthesis

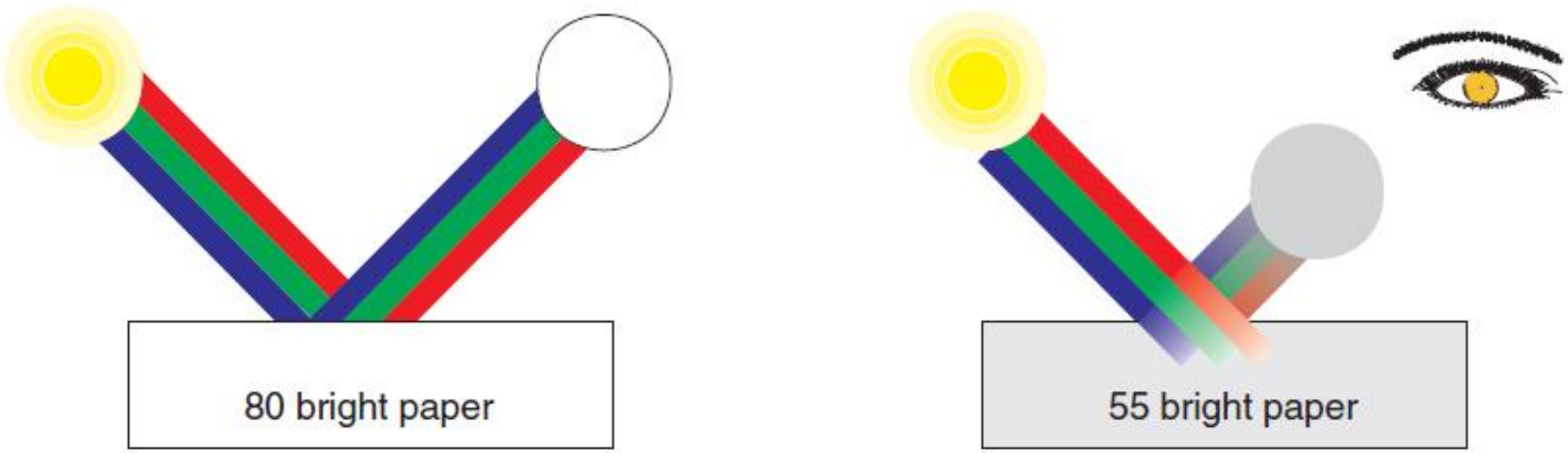


Figure 4.6
Brightness is a measure of total reflected light. In the illustration above, two papers exposed to the same light source both reflect red, green, and blue wavelengths. However, the amount of red, green, and blue reflected back from the 55 bright paper is less than from the 80 bright paper. Although still described as being white, the 55 bright paper will appear less bright or duller.

Viewing Color

- Color perception depends on:
- Light Source
  - Incandescent lights are rich in red
  - Fluorescent lights are deficient in red
- Nature of Object being viewed
  - Surface texture, gloss, adjacent color effect reflection
- Observer (the greatest variable)
  - Color blindness,
  - Interpretations by brain based on experience

4 Color Process Printing

- Blends 3 primary colors plus black to achieve the full color spectrum in a dot pattern
  - Black is added since full absorption of the red, yellow and green wavelengths is not possible and results in a dirty purple-brown color
- Decreasing dot size reduces saturation and lightens the perceived color
- Brightness of the substrate significantly impacts saturation

4 Color Process Printing

Figure 4.14
Color chart for four-color process printing.

Artwork

- Any drawing, illustration or graphic effect to be imparted to a substrate.
- Three categories based on how colors are presented in the final product
  - Line art
  - Half Tone
  - Process printed art

Line Art

- Solid lay down of a single hue
- Multiple colors can be used but they do not mix
- Typical uses:
  - Type copy, Diagrams, Line Illustrations, Solid blocks
- 1 printing plate for each color
- Color selected from Pantone Matching System color guide; drawdown used to color correct

Continuous Tone and Half Tone

- Printing a single color in a dot pattern allows saturation to be reduced by reducing the dot size
- On white paper the perception is a lighter and lighter color
- For half-tone printing, solid art is exposed through a screen to produce the photographic printing plate.
- Screen size is matched to the printing process

Continuous Tone and Half Tone

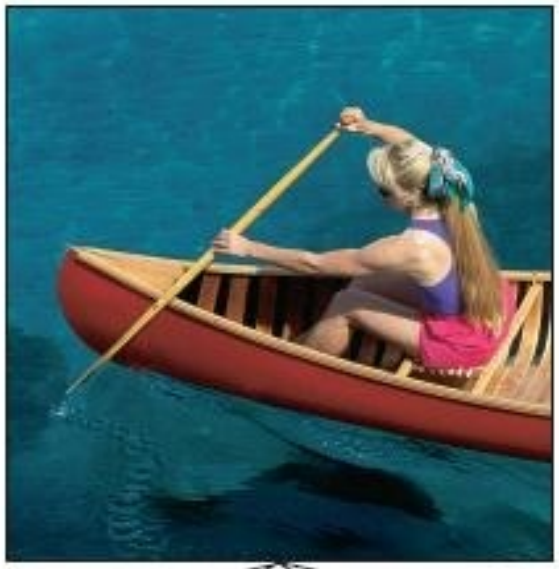
Printing Method	Typical Screen Range
Screen Printing	40 – 110 dpi
Flexography	60 – 150 dpi
Lithography/gravure	133 – 200 dpi

Process Printing

- Most complex printing task is reproduction of a full color illustration
- Mixing inks to match an artist mixing paint colors is not technically possible
- Using half-tone printing with the 4 process colors allows the eye to mix the individual dots and see the blended color
- Original art is separated into 4 screened printing plates
- Superimposing the 4 printing passes will reproduce the original art in the minds eye
- Colors are printed a different angles to prevent formation of moiré (wavy) pattern

Process Printing

Figure 4.15
The components of a full-color illustration, showing the effect of different screens.



Process color reproduction of a full-color original photograph. This one is printed with a 133-line screen.

magenta component

cyan component

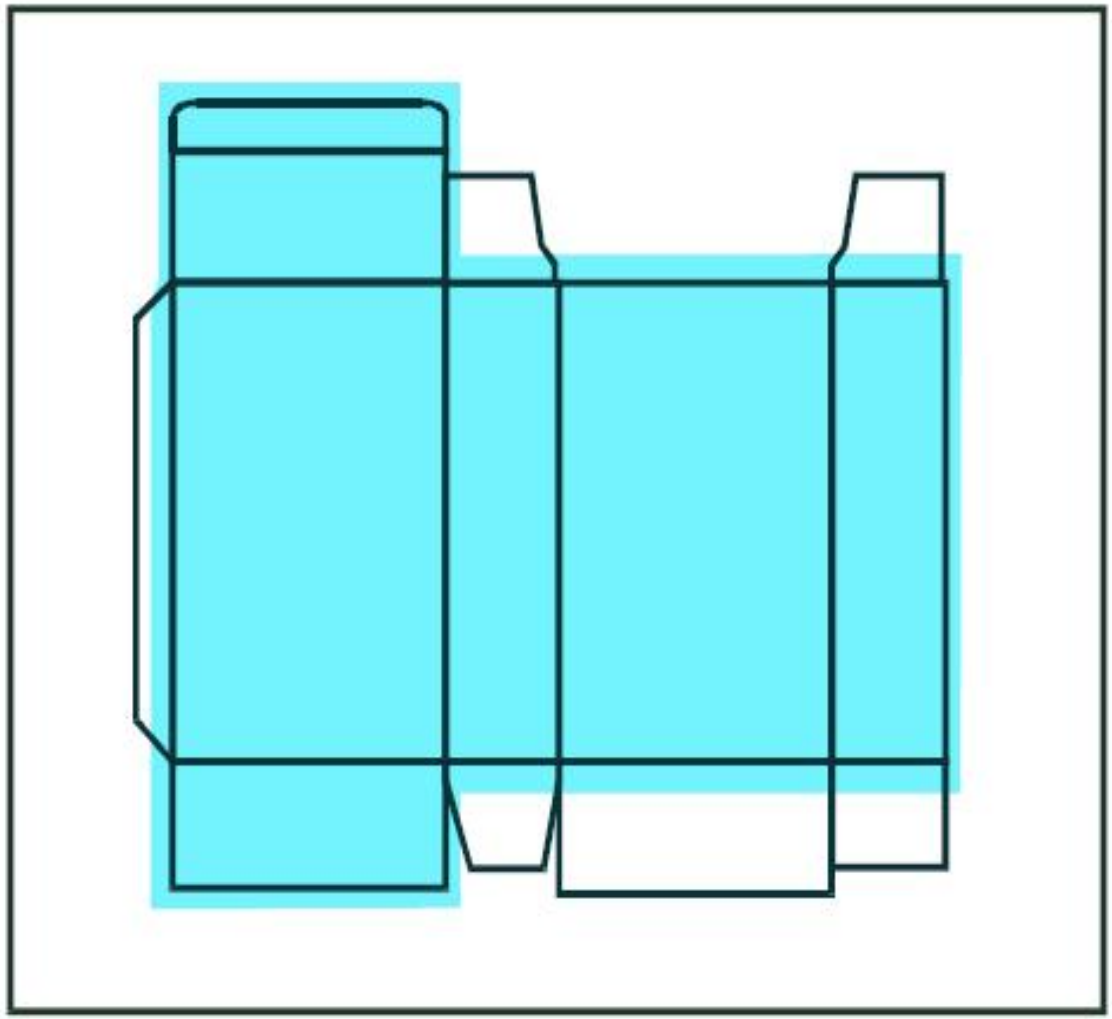
yellow component

black component

+ Preparation for Printing - Prepress

Figure 4.18

"Bleed" compensates for printing plate, substrate and cutting-die movement. The printed area on the paperboard carton blank "bleeds," or extends, slightly beyond cut or visible edges.



Preparation for Printing - Prepress

- Printing is not placed over glue areas to avoid contamination of the gluing process
- The printing press must have one station for each color printed
  - Line colors
  - Process colors
  - Press varnish
- Multiple printing passes may be required if the number of colors exceed # of stations on a press or more than one type of printing is required.

Color Keys

Print Quality Diagnostic Page

Printer Information

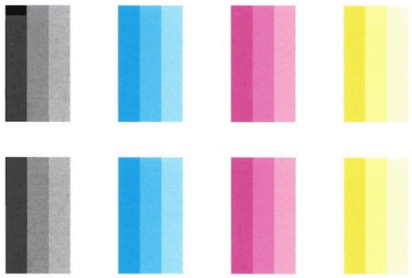
Product model number: CM749A
Product serial number: CN1AJ1T26P05KC
Service ID: 22041
Firmware Version: CLP1CN1150CR
Pages printed: Tray 1=2090, Tray 2=0, Total=2090, Auto-duplex unit=569
Ink cartridge level*: K=30, Y=90, M=90, C=80
*Estimates only. Actual ink levels may vary.

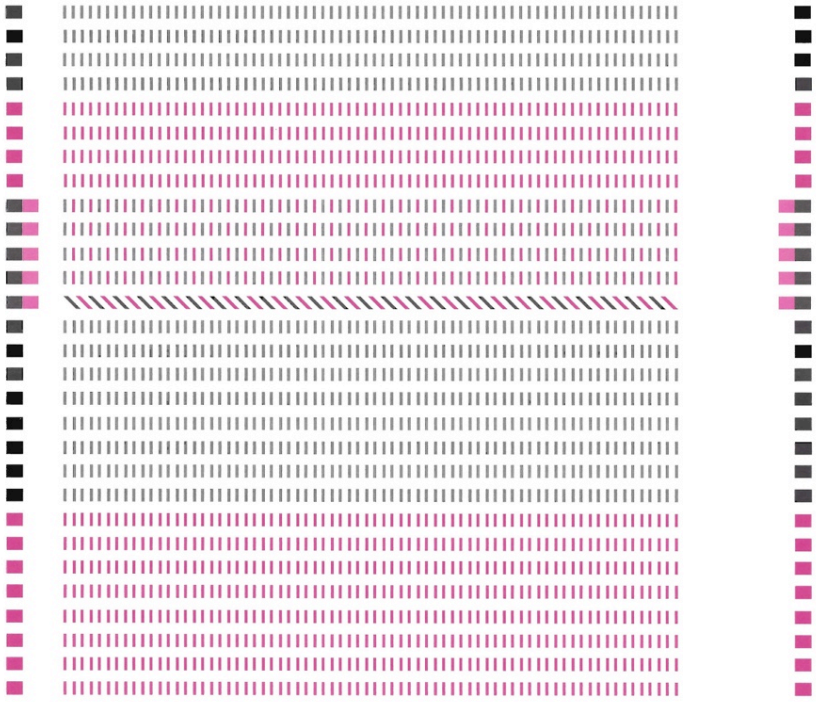
Test Pattern 1

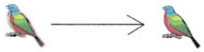
If the lines are not straight and connected, align the printheads.

Test Pattern 2

If you see thin white lines across any of the colored blocks, clean the printheads.







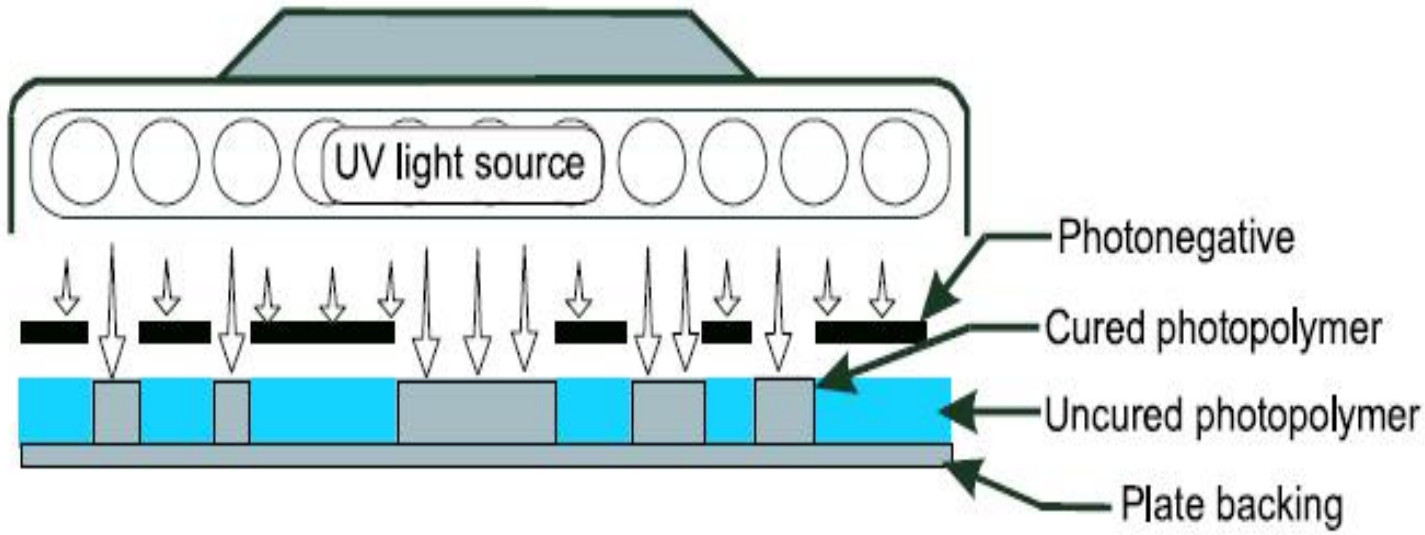
Printing Methods

- **Relief Printing (raised plate impressions)**
  - Direct transfer of ink from plate to substrate
  - Flexography, letterpress, offset letterpress
- **Planographic Printing (flat printing plate)**
  - Intermediate plate transfers ink (Blanket) from flat printing plate to substrate
  - Offset Lithography
- **Gravure (engraved cylinder plate)**
  - Engraved cylinder transfers ink directly to substrate
  - Roto Gravure
- **Digital Printing**
  - No printing plate
  - Short runs

+ Relief Printing – Plate making

Figure 4.19

UV light projected through the image photonegative will cure photopolymer. Uncured photopolymer can be washed away, leaving the raised image areas.



Relief Printing – Plate making

- Printing Plate Material
  - Rubber, Metal, Photopolymer
  - Plate is exposed to UV light through a film negative
- Ablation; Digital Computer to Plate technology
  - Plate with photosensitive polymer is coated with an opaque carbon material
  - Computer driven lazar burns away the carbon coating where the image is desired
  - Whole plate is exposed to UV light to cure the photopolymer where carbon is burned away
- Printing Plates are mounted to a printing cylinder with an adhesive

+ Flexographic Printing

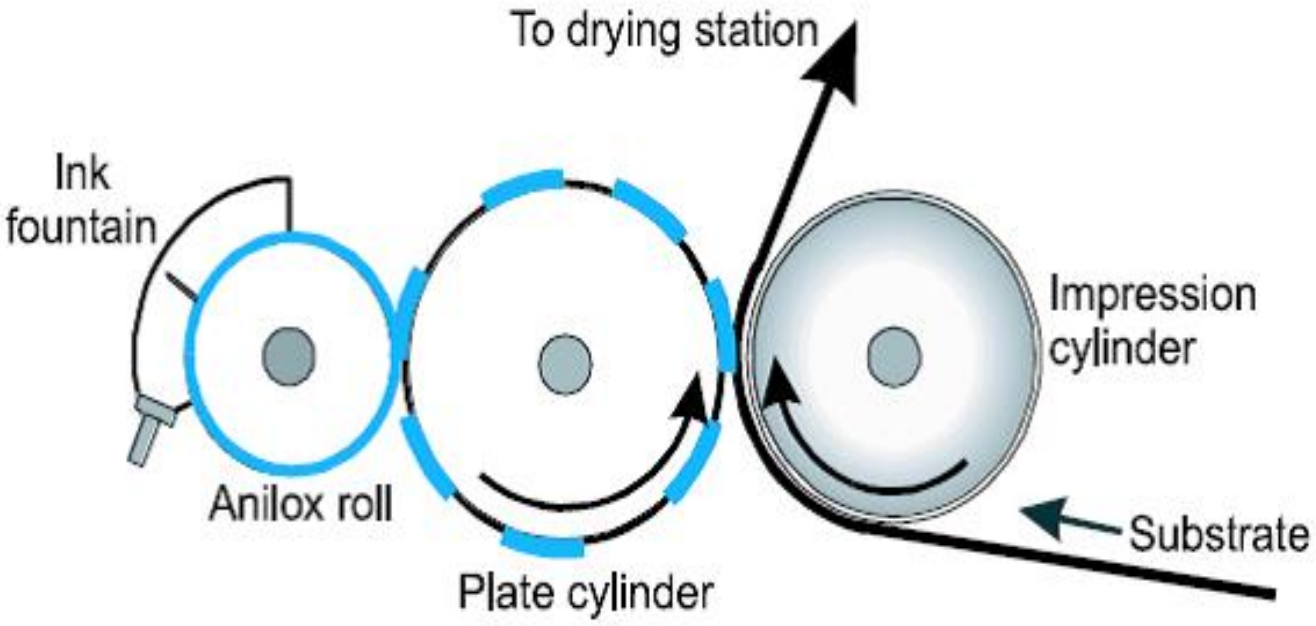


Figure 4.20

A typical flexographic print deck. Here, a chambered doctor blade ink fountain applies ink to the anilox roll. In other systems, ink is applied with rolls rotating in the ink fountain.

Flexographic Printing

- Anilox or Transfer Roll
  - Engraved to accept ink in engraved wells
  - Ink volume is controlled buy engraving depth and geometry
- Ink transfers to raised surfaces of printing plate
  - Line art has a smooth, solid plate surface
  - Process or half tone art has raised dots
- Flexography, by definition, uses a flexible printing surface
  - Pressure variation can cause the image to spread or gain resulting in color variation

Flexographic Printing

- Mixed fine lines and large solid print areas on the same plate present a problem using a correct pressure
- Rubber stamp nature of Flexography make it the printing process of choice for rough or textured surfaces
  - Corrugated fiberboard & Kraft linerboard

Flexographic Printing

- Flexographic Printing Strengths
  - Prints well on rough uneven surfaces
  - Better suited to low strength light weight substrates
  - Wide ink formulation latitude
  - Prints large solid areas evenly
  - Printing plates are low cost and readily made
  - Better than lithography but not as good as gravure for printing solid areas

Flexographic Printing

- Flexographic printing limitations
  - Sensitive to changes in printing pressure
  - Halo effects
  - Screen dot sizes not as fine as Litho or Gravure
  - Halftone gain is greater than Litho or Gravure
  - Highlight halftone dots tend to disappear; shadows fill in
  - Difficult to make halftone transitions in vignettes
  - Not as good as Litho for fine lines; better than Gravure

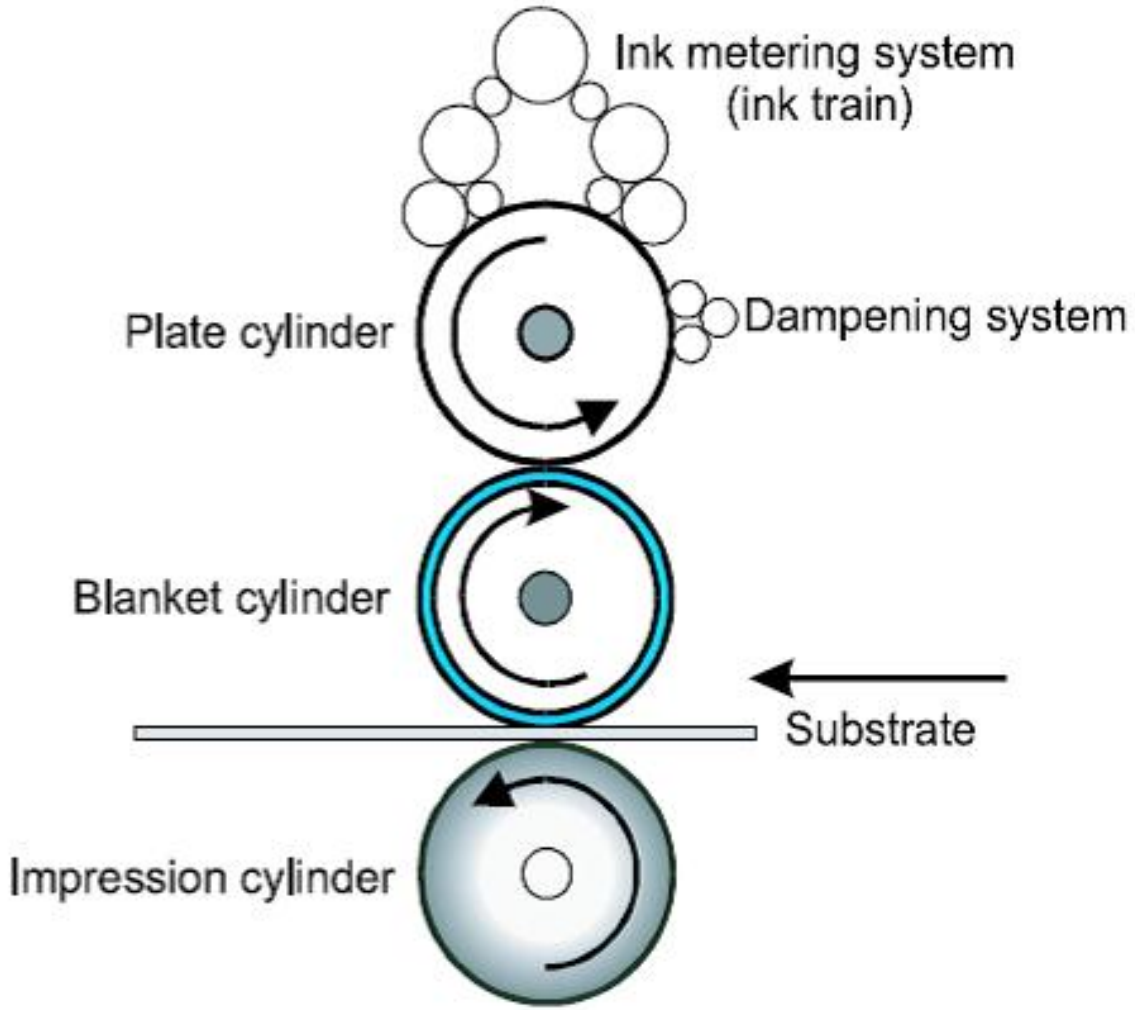
Lithography

- Lithography
  - Planographic process
  - Print and non-print areas are on the same plate
  - Plate is flat and smooth
- Printing plate
  - Aluminum alloy plate with photo-chemically developed oil-receptive and water-receptive areas
  - Oil based ink adheres to oil receptors and is repelled by water adhered to the water receptors
- Plates are mounted to a printing cylinders

Lithographic Printing

Figure 4.23

A lithographic printing station.



Lithographic Printing

- Group of rollers apply a thin coat of water to the water receptors on the printing plate
- Pasty, oil-based ink is applied to the printing plate by another group of rollers
- Ink image is transferred (offset) to a rubbery blank roll for more effective transfer to the substrate
- Impression cylinder provides contact pressure for transfer of ink from blanket to substrate

Lithographic Printing

- Paper requires certain amount of water resistance
- Paper stock:
  - Strong clean surface
  - Good anchorage of surface fiber
  - Clay coating to resist being picked or pulled apart by heavy ink as blanket separates from substrate
- Sheet Fed
- No driers, ink must dry overnight
  - Drying facilitated by drying powder; holds sheets separate

Lithographic Printing

- Lithographic printing strengths
  - Plates economical and readily made
  - Replacement or correction of plates is easy
  - Economical for small runs
  - Capable of fine lines and holding highlight halftones better than Flexo or Gravure
  - Exceptionally fine halftone screens
  - Prints well on metal surfaces
  - Low halftone dot gain and excellent registration
  - Some color adjustment available on-press

Lithographic Printing

- Lithographic Printing Limitations
  - Paper stock needs to be exceptionally clean
  - Paste inks make printing on light weight substrates difficult
  - Oil based inks dry slowly
  - Ink formulations are limited (oil based)
  - Color can vary across sheet
  - Printing of plastic substrates is difficult due to oil based nature of inks
  - Complicated process requiring skilled press operators
  - Does not produce large solid print areas as well as Flexo or Gravure
  - Sheet fed litho is slower that web fed Flexo or Gravure

Lithography Video

- https://youtu.be/hzMXEpjh5AE

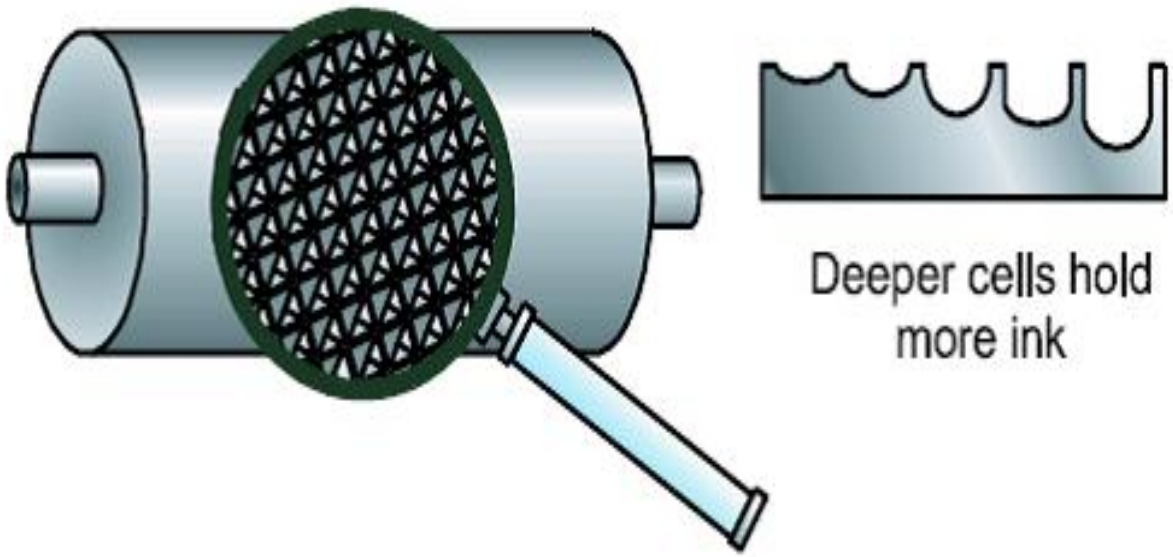
Gravure Printing

- Gravure printing uses an engraved cylinder
  - Copper plated steal cylinder
  - Digitally controlled stylus engraves cell pattern in soft copper
  - Chrome plated to harden the surface
- Printing process
  - Gravure cylinder is flooded with ink and doctor bladed
  - Direct transfer to web fed substrate

+ Gravure Printing

Figure 4.24

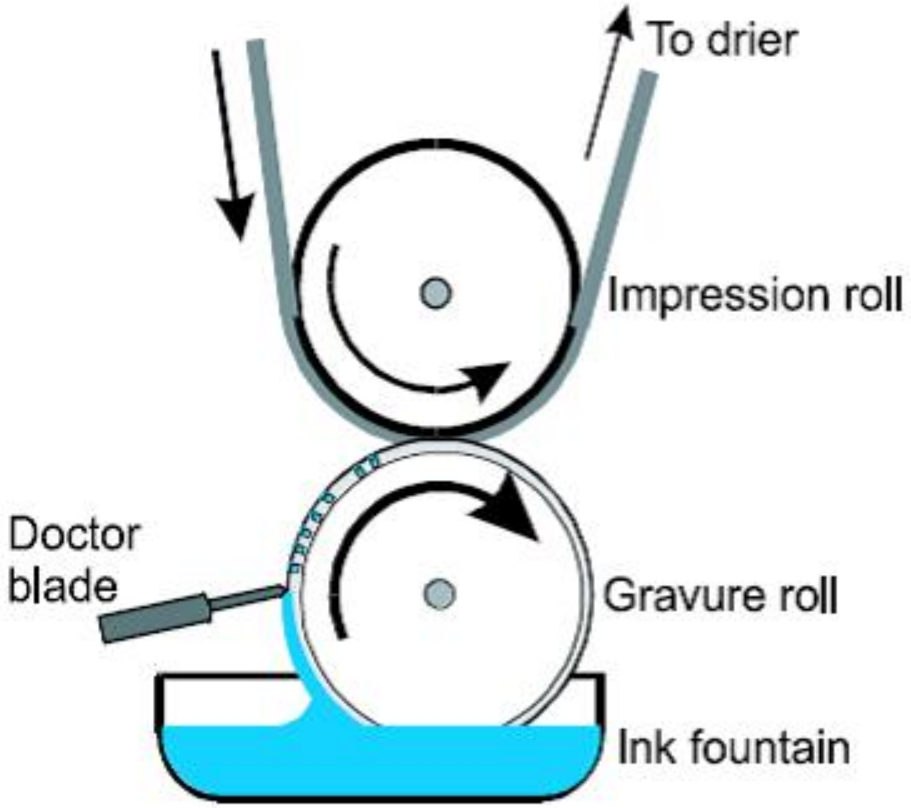
A gravure cylinder may have millions of tiny cells or wells whose volume can be controlled to carry different amounts of ink.



Gravure Printing

Figure 4.25

A gravure print station is mechanically simpler than either flexography or lithography.



Gravure Printing

- Gravure Printing Strengths
  - Very high speeds
  - Exceptionally fine halftones
  - Color consistency over long runs
  - Engraved cylinder allows different ink thicknesses
  - Heavy ink applications -> bright glossy colors
  - Can print heavy pigmented metallic inks
  - Superior for uniform heavy solids
  - Durable cylinders (millions of repeats)
  - Cylinders can be stored for re-runs
  - Continuous repeat is readily available

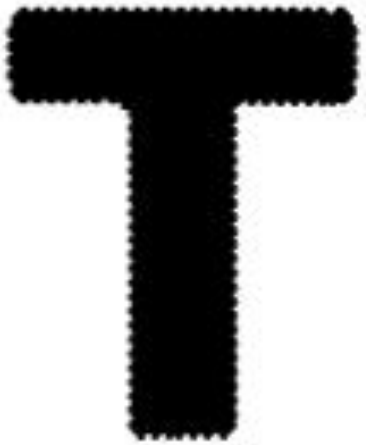
Gravure Printing

- Gravure Printing Limitations
  - Cylinder preparation requires long lead time
  - Cylinders very expensive
  - Does not print well on rough surfaces
  - Does not give good resolution of fine lines
  - Storage of cylinders is costly

Printed Appearance

Flexo Printing
"halo" effect

Litho Printing
smooth edges



Gravure Printing
saw-tooth edges

Digital Printing

- Digital printing is a method of printing from a digital-based image directly to a variety of media. It usually refers to professional printing where small-run jobs from desktop publishing and other digital sources are printed using large-format and/or high-volume laser or inkjet printers.

Digital Printing Video

- https://youtu.be/GctFIxIjM7Q

Other Decoration Techniques – **Hot Stamping**

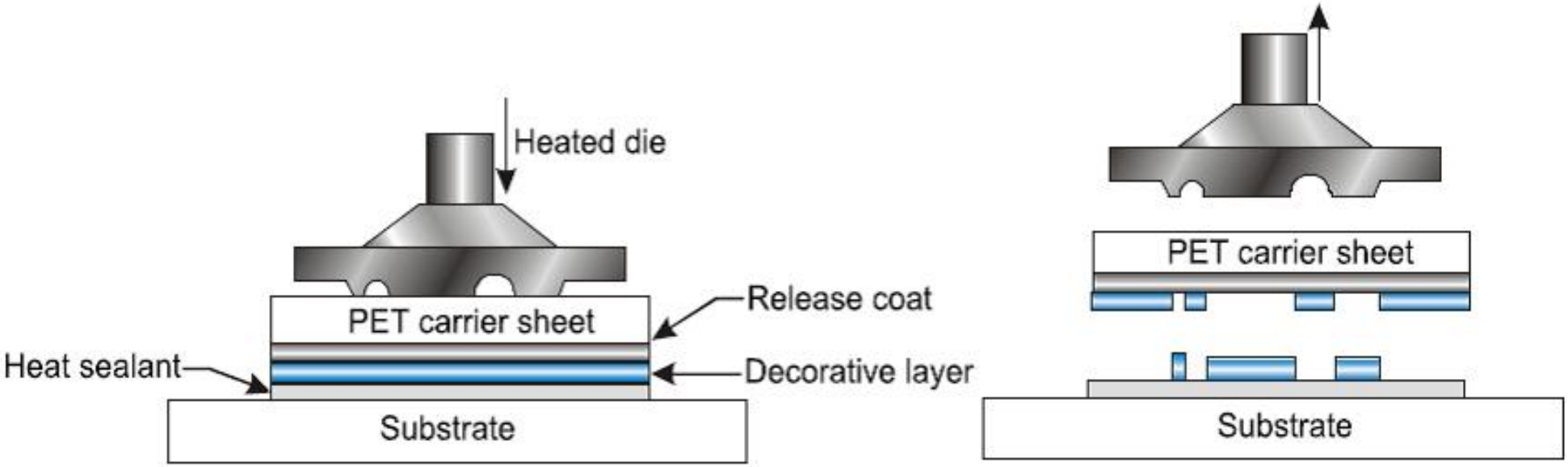


Figure 4.27

Hot-stamp printing uses a heated die that has the image engraved into its surface. Hot-stamp printing transfers only one color.

+ Printing Dimensional Packages – **Tubes (Dry Offset)**

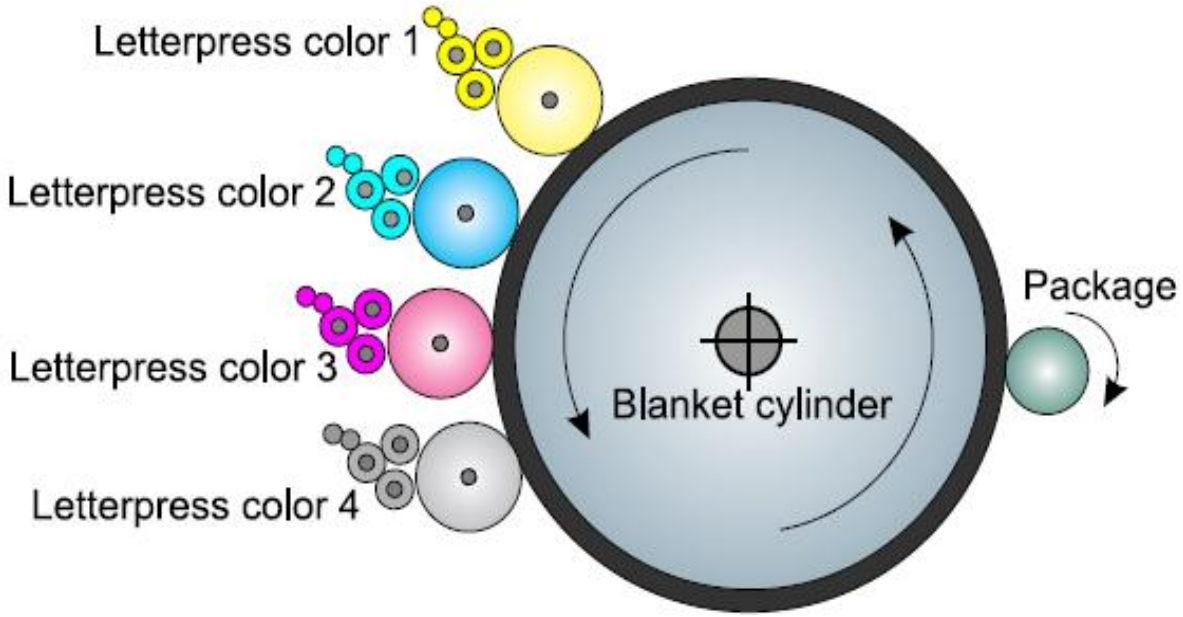


Figure 4.28

Offset letterpress (dry offset) assembles the entire image on a blanket roll and transfers the image to a round container in one rotation of the container.

+ Printing Dimensional Packages – **Silk Screening**

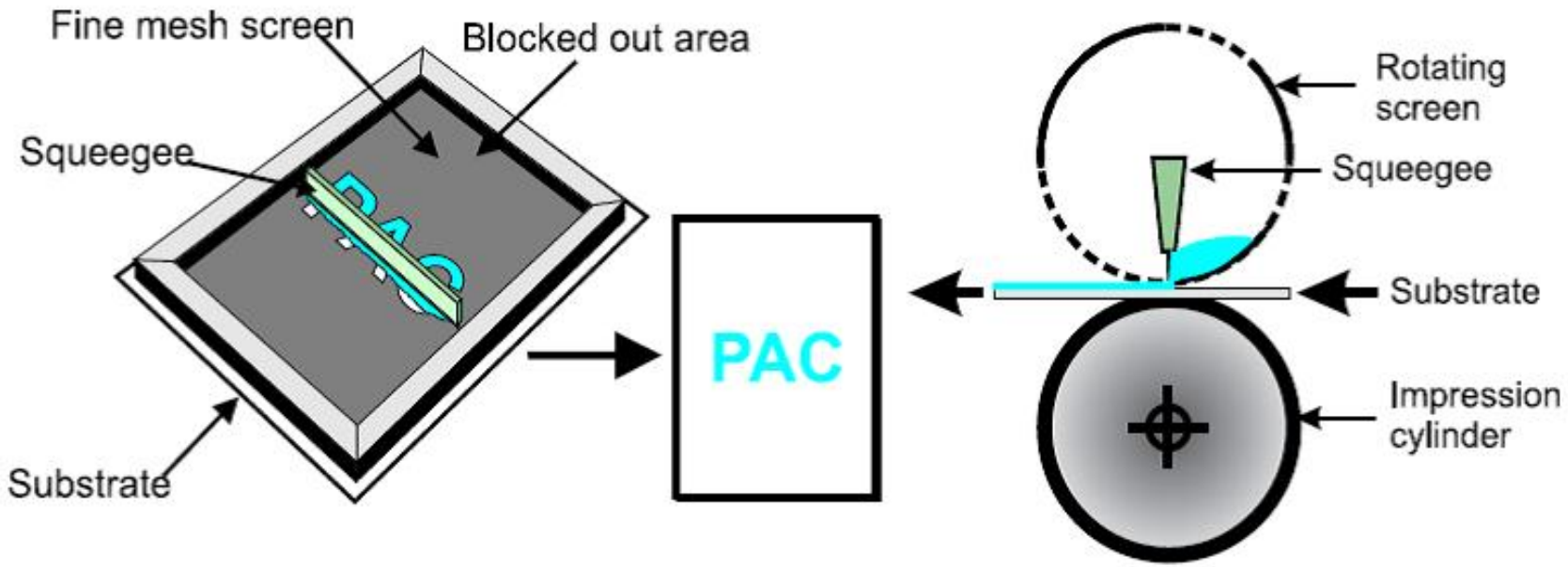


Figure 4.29

Flat framed screens (left) are used for very large area application such as point-of-purchase displays. printing can be done on flat or round objects. Rotary screens (right) are use for smaller higher volume applications.

Printing Dimensional Packages – **Silk Screening**

- Advantages of Screen Printing
  - Image carrier (printing plate/Screen) inexpensive and quickly prepared
  - Great variety of ink formulations
  - Print any substrate
  - Heavy ink lay-down
  - Large solid areas are uniformly opaque
  - Print cylindrical or tapered shapes
  - Very large image carriers are possible

Printing Dimensional Packages – **Silk Screening**

- Screen Printing Limitations
  - Production speeds very low
  - Heavy ink lay-down increase costs
  - Not able to produce fine halftones

+ Printing Dimensional Packages – **Pad Printing**

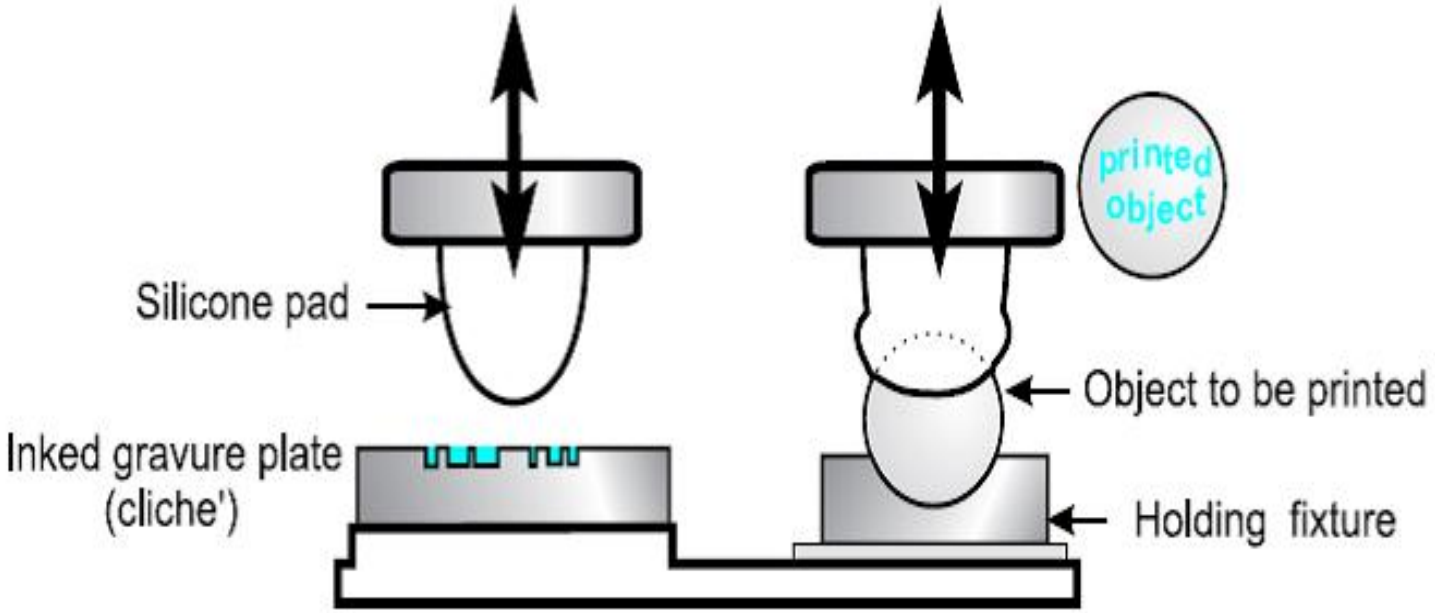


Figure 4.31

Pad printing is used to decorate irregularly shaped objects. The pad is first pressed against the inked cliché and then moved over and pressed against the object to be printed.

Labeling

- Labels
  - Image printed on a separate material that is attached to the package by a means other than printing (adhesive, heat transfer, etc.)
- Cut and Stacked Labels
  - Paper or laminate stock sheet
  - Applied with water based adhesives in line
  - Allow low cost handling of many inventory variables
  - Not used in Pharmaceutical industry due to risk of mixed labels

+ Labels

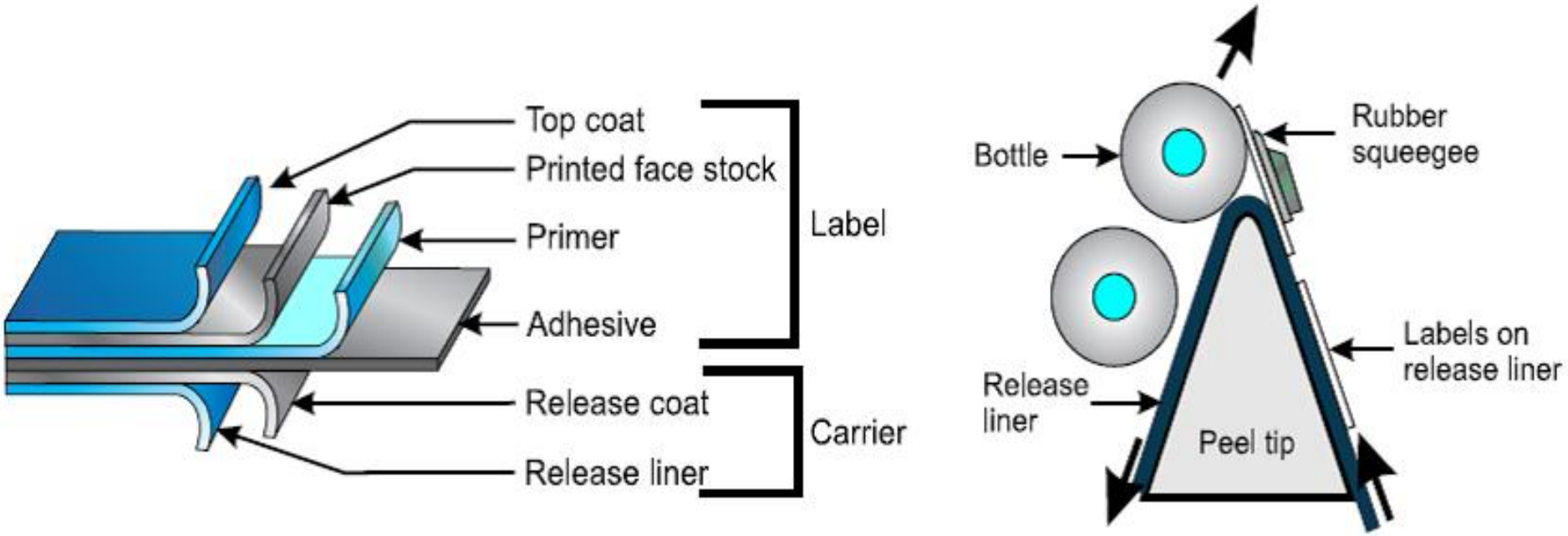


Figure 4.32

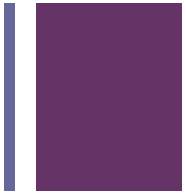
Typical pressure sensitive label construction. The label is peels away from the liner when it is passed around a sharply angled peel tip.

Labels

- Shrink Sleeves
  - Printed on plastic material that shrinks when exposed to heat
  - Tubular sleeves formed by extrusion blowing the film tube or solvent bonding flat extruded PVC or PETG.
  - Flat stock is reverse printed before forming
  - Heat sensitivity can impact on label storage
  - Printing can have complicated prepress
  - Filling speeds are reduced

Labels

- In-Mold labeling
  - Sheet fed or single adhesive coated labels are placed in an injection or blow mold
  - Mold is closed and plastic injected or blown
  - Hot plastic activates the adhesive
  - Ejected part is pre-labeled and requires no labeling equipment on the filling line
- Disadvantages
  - High tooling cost, slow molding cycle, contaminated regrind, bottle shape limitations, inventory cost of pre-decorated containers



Questions?

Thank You

And

Have a Good Day